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EDITORIAL

THE MEDITERRANEAN FRUIT FLY

THE Mediterranean Fruit Fly, known to the entomologist as *Ceratitis capitata*, was discovered in two large consignments of citrus fruit received in Colombo from Palestine early this month. These two consignments were destroyed, and arrangements have been made for the inspection before landing of all consignments of fruit that may be received from the same country during the present export season.

The public can hardly realize how great was the danger to horticultural development in this country which was thus narrowly averted. The Mediterranean Fruit Fly does not thrive in temperate and cold climates. But in all countries with tropical or semi-tropical climates in which it became established it has proved to be one of the most important, if not the most important, insect enemy of the fruit grower. It has made its home in all the Mediterranean and Red Sea countries, the whole of Africa, Western Australia, New South Wales, Queensland, Brazil and Argentina, Bermudas and the Hawaiian Islands. The only countries which have been able to eradicate it after it established itself are New Zealand, Tasmania, and the United States of America (Florida).

The adult fly lays its eggs just beneath the epidermis of the ripening fruit through a small puncture in the skin so inconspicuous that it escapes notice. The larvae hatching from these eggs eat their way through the pulp right to the pit or core of the fruit. Thus one may cut open a fruit which appears

perfectly sound externally, and find that it contains maggots, while the pulp is tunnelled with passages which are lined with decayed tissues. The fly does not appear to show much discrimination in the choice of a host for its eggs. There is hardly any known edible fruit which is not subject to attack, though the mango, the banana, the papaw and other similar tender fleshed fruits show the most susceptibility, while the epidermis of the pineapple appears to present an impenetrable barrier.

Ceylon has just awakened to the part which horticulture should play in the economic life of the people. It is the hope of the agricultural department to develop what is at present only haphazard traffic in casually produced fruit to a lucrative planned industry. The introduction of the Mediterranean Fruit Fly would put an effective check to all such attempts. It appears to be necessary to enforce the strictest quarantine regulations to prevent such a development. The choice is between the absolute prohibition of fruit imported from infested countries, or the creation of an organization for the detailed inspection of all imported fruit before landing, and the immediate destruction of all consignments which show signs of being affected. Since practically all countries from which we import fruit are affected the former alternative is hardly practicable, while the expenditure involved in enforcing effective quarantine will be considerable. At present the country appears to have no alternative but to face the prospect of the necessary expenditure on quarantine.

ENTOMOLOGICAL NOTES—II.

SOME COMMON INSECT PESTS OF FRUIT TREES

CONTRIBUTIONS FROM THE ENTOMOLOGICAL DIVISION, PERADENIYA, CEYLON

MANGO PESTS (*Continued*)

LEAF-EATING CATERPILLARS

MORE than one dozen different species of caterpillars have been recorded as attacking the leaves of mango in Ceylon and the damage is usually done to the tender young leaves before these have become too hard to be palatable. As a rule only a few caterpillars of one or two species may be found at the same time and very little damage is done beyond the partial nibbling of a few leaves here and there. Individual caterpillars can usually be picked off and destroyed if the trees are small. Sometimes, however, young plants may receive a serious set-back if all their tender foliage is stripped or their growing shoots are eaten away, or older trees may have masses of their leaves webbed together and skeletonised.

A common minor pest of young mango leaves is the caterpillar of the noctuid moth, *Bombotelia jacosatrix*. The larvae are yellowish-green with numerous small purplish-brown spots ; the pupae may be formed in the soil.

Another occasionally troublesome pest is the mango pyralid *Orthaga euadrusalis*, sometimes known as the mango leaf-webber. This pest may sometimes become quite conspicuous if left undisturbed on older trees, since the leaves of several adjoining shoots or small branches may be gradually drawn together by a tangled web of loosely woven white threads to form a large " nest ". The moths lay their flat scale-like eggs singly on the leaves and the eggs hatch in about 1 week. The larvae gradually web the leaves together and a number of larvae may live together within the webbed mass of leaves which they gradually skeletonise ; the full-grown larvae consume portions of the older leaves. The larval period lasts about 5 weeks. The pupae are formed within the " nest " in cocoons covered with frass. The moths emerge in about 3 weeks and

the females live about 1 week, starting oviposition within 2 or 3 days after emergence. Six females laid an average of 194 eggs. Adjoining "nests" are sometimes joined up to form an unsightly mass of dead and dying leaves and excrement; fresh leaves are taken into the mass when needed for food. In such cases, the only remedy is to cut out the whole mass including sometimes several branches, and burn it. This pest should be controlled in the early stages of an attack by spraying with lead arsenate.

Other occasional pests of young leaves are two species of geometrids, or loopers, *Boarmia acaciaria* and *Thalassodes quadraria*, and the blue-striped nettle-grub (*Parasa lepida*).

The shoot-boring caterpillar (*Leucinodes orbonalis*), a common pest of brinjal (*Solanum melongena*) and other Solanaceae, is sometimes a nuisance on mango trees. This is a difficult pest to control, since its presence is seldom detected until the shoots begin to wither and die. Cutting off and burning the attacked shoots is a partial control, but on young trees regular spraying with the combined spray will prevent attack.

PESTS OF MISCELLANEOUS FRUIT TREES

Although the different species of citrus and varieties of mango are probably the two most important groups of fruit trees in Ceylon, there are a number of other fruit trees which are being grown or can be grown in small numbers in individual gardens or over larger areas in orchards. Notes on the cultivation of most of the following fruit trees are given in the series of articles by the Curator, Royal Botanic Gardens, which appeared in *The Tropical Agriculturist* from June, 1932 to March, 1933. In those notes full details are given as to the types of soil and climatic conditions under which the trees are best grown, the methods of planting, spacing and various cultural requirements, and if the recommendations given therein are followed it should be possible to produce well-grown vigorous trees capable of bearing good crops in season.

In spite of all the necessary attention to cultural details it sometimes happens that these various fruit trees are attacked by insect pests. The injury caused is rarely of a vital nature, but it may be sufficient to retard their growth or cripple their normal vigour especially in the case of young trees growing in unsuitable soil conditions. The regular application of insecticides during the early years of growth will prevent attack by such pests as small leaf-eating caterpillars and beetles and by

such sucking insects as scales, aphids, etc., similar to those previously mentioned under citrus and mango. It should be realised that many of these fruit-tree pests are commonly distributed on many wild and cultivated plants and there is no practicable method of preventing attacks on young fruit trees except by the routine applications of insecticides. These young trees must be protected from insect pests during their early years of growth if they are to develop normally, but after they have reached the fruit-bearing stage the protection of the blossoms and fruit from attack becomes the first consideration, although sometimes emergency measures have to be taken to control leaf-eating pests as well.

The various insect pests are listed under their host plants, these being arranged according to the alphabetical order of their botanical names. Where possible, simple control measures are given for each pest or group of pests. It should be emphasised that any increase in the area under any one species of fruit-tree or any group of related fruit-trees, such as different species of citrus or varieties of mango, is usually followed by an increase of insect pests in that area, involving more intensive control measures over the whole area.

SAPODILLA (*Achras Sapota*)

On the whole this tree is remarkably free from insect pests, and it has not been possible to make any special study of the few that have been recorded. Leaf-eating caterpillars on young trees can be controlled by the lead arsenate spray. A fruit-boring caterpillar, as yet unidentified, occasionally attacks the fruits, but until more is known about its habits, the only remedy is to destroy any damaged fruit. Green bug (*Coccus viridis*) is the commonest pest and can be controlled by an oil emulsion of a fish-oil-resin soap spray. The presence of this scale is usually detected by the blackened appearance of the leaves due to sooty mould.

CASHEW NUT (*Anacardium occidentale*)

On older trees the fruit is sometimes attacked by boring caterpillars (*Phycita leuconeurella*). The purplish larvae, sometimes as many as four in a fruit, destroy the fleshy portion, so that the attached nut fails to develop normally. Infested fruit should be destroyed daily, as in the case of fruit-fly.

Cashew seedlings are sometimes riddled by a stem-boring caterpillar (*Ctenomeristis ebriola*) which causes die-back and

sometimes kills the plants. Spraying with lead arsenate or nicotine sulphate may be effective, if started when the seedlings are quite young.

The young leaves are occasionally badly spotted and shrivelled up by plant-sucking bugs, probably *Disphinctus humeralis*. Spraying with nicotine-sulphate as soon as the attack is noticed should control this pest.

CHERIMOYER, ETC. (*Anona* spp.)

The fruit may be attacked by fruit fly, apparently a subspecies of *Dacus ferrugineus*, which can be controlled by poisoned bait and daily destruction of infested fruit, as in the case of citrus and mango fruit-flies.

Soursop (*Anona muricata*) is attacked by leaf-eating caterpillars, those recorded being *Papilio agamemnon; Lamprosema indicata; Aetholix flavibasalis* and the tea tortrix (*Homona coffearia*). The above species are only occasional minor pests and usually no special control measures are necessary beyond the removal of individual specimens. Senior-White records a serious attack by an undetermined psychid or bag-worm, and for an outbreak of this nature the lead arsenate spray is indicated.

This tree and the related custard apple (*Anona squamosa*) are sometimes damaged by the red borer (*Zeuzera coffeae*), a pest of a great variety of cultivated plants, including tea, coffee, cacao, citrus, etc. Full details of this pest are given in *The Tropical Agriculturist* for September, 1932, pp. 137–148. The reddish caterpillar tunnels in the branches which usually wither. Young plants may be killed if the larva is not detected in time. Control measures include the removal and burning of attacked branches, or in cases where the main stem is attacked, the injection of petrol into the tunnel.

The various species of *Anona* are attacked by several species of scale insects which are usually found on the leaves and twigs. The presence of sooty mould is usually an indication of the prevalence of these pests. Spraying with an oil emulsion or a fish-oil-resin soap spray and the improvement of the soil conditions are the usual remedies. The commonest scale is the black scale (*Saissetia nigra*) which is periodically controlled by natural enemies, including the small chalcid wasp (*Scutellista cyanea*). Other species of scales *Saissetia oleae; Coccus longulus; Lecanium marsupiale; Icerya aegyptiaca* and *Pseudococcus citri*, the latter sometimes clustering on the fruit.

TREE TOMATO (*Cyphomandra betacea*)

This is a shrub or small tree, usually grown up-country, sometimes receives a severe set-back owing to the attacks of the root-eating ant (*Dorylus orientalis*). This pest seems to be common in many up-country gardens and is most difficult to eradicate. It is the slender reddish worker ants which do the damage by boring into the roots and collars of young trees and feeding on the underground portions of numerous ornamental and vegetable plants, especially those with tuberous or bulbous roots. Much can be done to prevent serious attack on annual crops by fumigating the soil with petrol before planting, but in the case of attacked trees a more slow-acting soil fumigant, such as paradichlorobenzene, is indicated. For fuller information on this pest, reference should be made to *The Tropical Agriculturist* for May, 1933, pp. 276–279. Occasional pests of tree tomato are the coreid bug, *Leptoglossus membranaceus*, which can be swept off into tins of kerosene and water, and the mealy-bug *Pseudococcus virgatus*, which can be sprayed with an oil emulsion.

LOQUAT (*Eriobotrya japonica*)

This tree may be attacked by two kinds of boring insects, the red borer, previously mentioned under *Anona*, and a species of termite (*Glyptotermes dilatatus*), one of the common tea termites, about which much has already been written in Departmental publications. Injury to young plants by either of these pests may sometimes prove fatal, but in older trees the damage may be confined to the branches. The termites can be kept in check by the removal of infested portions and of dead snags and by the treatment of all wounds with a wood preservative.

Two plant-sucking insects sometimes found on loquat are the large aphid, *Lachnus pyri*, and green bug (*Coccus viridis*), against which the usual contact sprays are effective.

FIG (*Ficus Carica*)

The cultivated fig tree is attacked by the same species of leaf-eating caterpillars as are found on ornamental and wild species of *Ficus*. The most important of these pests are the larvae of a bombycid moth (*Ocinara varians*) which sometimes strip the leaves of young fig trees, which may be seriously crippled unless the outbreak is controlled by spraying with a soap solution at the rate of 1 lb. to 8 gallons for the young larvae and 1 lb. to 6 gallons of water for the older larvae. The

lead arsenate spray would also be effective. Spraying is only practicable on fairly small trees. This caterpillar is also an occasionally serious pest in young plantations of jak (*Artocarpus integra*). Investigations on the bionomics of *Ocinara* indicate that the female moths begin egg-laying within 2 or 3 days after emergence and that 12 females laid an average of 307 eggs within 5 to 7 days. The eggs hatch in about 5 days and the larval period occupies from 18 to 44 days and the pupal period from 5 to 7 days. The life-cycle from oviposition to emergence of moths ranges from 4 to 8 weeks in captivity. The predaceous pentatomid bug (*Catheconidea robusta*) feeds on the larvae, while hymenopterous parasites, as yet unidentified have been bred from the pupae.

The caterpillars of *Hypsa caricae* and *Hypsa ficus* are occasionally troublesome and the blue-striped nettle-grub, (*Parasa lepida*) is also recorded. Full details of this nettle-grub are given in *The Tropical Agriculturist* for April, 1932, pp. 198–205. The leaf-rolling caterpillars of *Margaronia stolalis* and *Phycodes radiata* sometimes attack young fig trees.

MANGOSTEEN (*Garcinia Mangostana*)

Two fairly common caterpillar pests of this tree are *Stictoptera grisea* and *Stictoptera cucullioides*, while the tussock caterpillar (*Notolophus posticus*) is sometimes a minor pest. Information on this insect is given in the Yearbook of the Department of Agriculture for 1926, p. 19. Spraying with a stomach poison, such as lead arsenate, is practicable only on young trees. The star scale (*Vinsonia stellifera*) is occasionally found on the leaves.

AVOCADO PEAR (*Persea gratissima*)

The leaves and shoots of young trees are attacked by *Disphinctus humeralis* which has been mentioned in greater detail under mango in the first part of these notes appearing in the April number. Young grafted plants sometimes receive a serious set-back, since every leaf is badly spotted and shrivelled up as soon as it appears.

A small leaf-rolling weevil (*Apoderus tranquebaricus*) sometimes occurs on avocado, but is more common on mango leaves. The weevil lays an egg at the folded tip of a leaf and then cuts through both sides of the leaf to the mid-rib near the base and makes a tight roll of the cut terminal portion, the egg being in the middle of the rolled-up leaf. The small grub feeds inside the roll and the pupa is formed there in a mass of faecal pellets.

The weevil emerges later through a hole which it cuts in the side of the roll. The rolled-up leaves can be removed and burnt to prevent further spread of the pest.

Among caterpillar pests may be mentioned *Notolophus posticus*, a leaf-miner (*Acrocercops ordinatella*), and the red borer (*Zeuzera coffeae*). Fruit-fly (*Dacus ferrugineus*) is an occasional pest, and the usual remedies can be applied as soon as the attack is noticed.

GUAVA (*Psidium Guajava*)

Both wild and cultivated varieties of guava are attacked by a number of insect pests, the various scale insects being probably the most troublesome. Several leaf-eating caterpillars have been recorded, but none of them do any serious damage, although at certain times most of the young shoots and leaves may be nibbled, webbed together and rolled up by such caterpillars as the lasiocampids, *Suana concolor* and *Trabala vishnu;* the geometrids *Hyposidra talaca* and *Boarmia* sp.; the tea tortrix, *Homona coffearia;* and the leaf-roller *Spilonota rhothia.*

Stem and branch-borers include *Zeuzera coffeae* and the grubs of a chrysomelid beetle (*Sagra nigrita*). In the case of the beetle pest, the grubs tunnel in the branches and the cocoons are formed in the tunnel, the beetles eventually making their way out. The latter are leaf-eaters, sometimes attacking guava. This beetle is usually a pest of various kinds of bean plants, the grubs causing gall-like swellings in the stems.

Disphinctus humeralis is a common pest of guava leaves, being responsible for the usual spotting and shrivelling of young foliage.

Several species of scale insects are common on guava trees, which are frequently blackened by the inevitable sooty mould, giving them a most unsightly appearance. Among the commonest scales are green bug (*Coccus viridis*) ; brown bug (*Saissetia hemispherica*); *Pulvinaria psidii; Icerya aegyptiaca;* one of the wax scales (*Ceroplastes floridensis*) and a mealy-bug, *Pseudococcus lilacinus.*

The China guava (*Psidium cattleianum*) is attacked by *Pseudococcus virgatus.*

So far there have been no definite records of fruit-fly in guava fruit in Ceylon, but *Dacus ferrugineus* in its various subspecies is recorded from this fruit in India.

If better varieties of guava are cultivated on orchard lines, then spraying should be done regularly to control many of the above pests, especially the scale insects. Some of these are partially controlled by natural enemies.

POMEGRANATE (*Punica Granatum*)

Among leaf-eating caterpillars may be mentioned *Achaea janata*, a common pest of castor ; *Suana concolor* and *Nygmia flava*. None of these is serious as a rule, but outbreaks should be watched and prompt measures taken before the trees are stripped.

The only important pest of the fruit is the larva of the lycaenid butterfly, *Virachola isocrates*. The eggs are laid on the flowers and young fruit into which the caterpillar bores. The fruit is eventually riddled and destroyed, the pupa or chrysalis being formed inside. All attacked fruit should be collected and destroyed. It should be possible to protect specially good varieties of fruit by enclosing them in grease-proof paper bags, as recommended for grape-fruit in the February 1936 number of *The Tropical Agriculturist.*

A few species of scale insects are known to occur on pomegranate trees, notably *Chrysomphalus aurantii; Ceroplastes ceriferus* and *Icerya aegyptiaca.*

GRAPE-VINE (*Vitis vinifera*)

Leaf-eating pests include the leaf-roller (*Sylepta lunalis*) and the beetles *Microtrichia costalis* and *Scelodonta nitidula.* An occasionally serious pest of grape-vines is the stem-girdling beetle (*Sthenias grisator*). This is one of the cerambycid or long-horned beetles, the grubs of which are wood-borers. The beetle cuts a ring around a branch with its jaws and lays eggs in the bark above the cut. The grubs feed inside the slowly dying girdled portion of the branch and pupate inside the dead branch. Grape-vines may be severely damaged, sometimes losing many of their branches, the result being a somewhat drastic pruning. The beetles may be caught and killed, but are not easy to detect, as they rest quietly on a branch and drop to the ground when disturbed. They may hide among dead leaves either on the vine or on the ground. Dead and dying portions of the vine should be removed and burnt. A thorough spraying of the branches with the lead arsenate spray used for leaf-eating pests, may help to control this beetle and possibly prevent attack. The capsid bug (*Disphinctus humeralis*)

and a scale insect (*Ceronema koebeli*) are two of the sucking insects on grape-vines, while mites (*Tetranychus* sp.) are sometimes troublesome on the young leaves. A colloidal sulphur spray is useful against mites.

JUJUBE OR MASAN (*Zizyphus jujuba*)

This tree grows wild in the low-country dry zone areas, where it is sometimes utilised as a host plant for the lac insect (*Laccifer lacca*), and has not received much attention as a cultivated tree, except occasionally in the wetter mid-country districts. The tree is attacked by a number of leaf-eating insects, none of which cause serious damage, but their combined attacks contrive to give the trees a very ragged appearance. If ever the better grafted Indian varieties came to be grown locally for their fruit, it is probable that they would be attacked by many of the local insects found on this tree. Among the leaf-eating caterpillars are the fringed nettle-grub (*Natada nararia*); the tortrix caterpillars, *Homona coffearia* and *Adoxophyes privatana;* the lymantriads, *Nygmia flava* and *Nygmia scintillans;* and the geometrid *Dilinia medardaria*. Species of the leaf-eating weevils, *Myllocerus* and *Astycus* sometimes nibble the leaves and young shoots. Spraying with a stomach poison would be necessary for the better cultivated varieties of this tree.

GENERAL NOTES

The importance of routine spraying of young fruit-trees has already been emphasised and fruit-growers, especially those who are concentrating mainly on citrus and mango, must be prepared to start spraying as soon as their trees are planted. For this purpose they should equip themselves with efficient spraying machines and the necessary supplies of insecticides and fungicides, so that the applications can be made at regular intervals without interruption. This routine spraying of young fruit-trees for a few years before they come into bearing may be regarded by some fruit-growers as an unnecessary expense, but in view of the numerous insects, not to mention diseases, which invariably attack many young fruit-trees, especially citrus and mango, this type of expenditure should be regarded as an insurance against serious injury to or possible loss of their trees before they reach the fruit-producing stage. From then onwards the fruit has to be protected from other pests and diseases. These general principles are recognised in all countries

where fruit is grown commercially and must be accepted in Ceylon if fruit-growers are to obtain the best returns from their orchards.

Insecticides.—The foregoing notes on insect pests of fruit-trees have indicated that, apart from and certain boring insects which have specialised feeding habits, the two main types of these pests are *leaf-eating insects*, such as caterpillars, beetles, etc., which bite off and chew their food, and *sucking insects* which pierce the plant tissues and suck up the juices by means of a specially adapted beak or piercing and sucking organ. These are mainly plant bugs, aphids, scales, etc. Speaking generally, the old idea was that biting and chewing insects had to be controlled by the use of a "stomach poison," usually of mineral origin, such as lead arsenate, and that sucking insects required for their control some "contact insecticide," such as a soap spray or a mineral oil emulsion. A stomach poison is usually applied to the foliage, etc., with the object of killing the insects if they attempt to eat the poisoned food. A contact insecticide must be applied directly on to the insects, which are killed by asphyxiation, by corrosion of the body tissues, by paralysis of the nervous system, etc.

As a result of prolonged and intensive investigations of insecticides in some countries, involving new uses for old insecticides and the employment of many kinds of known poisons for insecticidal purposes, there are now available for general use several insecticides which may be said to serve the dual purpose of a stomach poison and a contact insecticide. Moreover, some insecticides formerly recommended only against sucking insects, are now recognised as being most useful in controlling many leaf-eating insects, such as small caterpillars, beetles and grasshoppers. In other words, some contact insecticides, especially those containing some vegetable poison, such as nicotine, derris or pyrethrum, have proved to be valuable insecticides for general use against most small plant pests.

Many so-called contact insecticides are now available on the market in a ready-made concentrated form which mixes easily with water at the ordinary temperature. These are mainly either mineral oil emulsions or liquid extracts of the vegetable poisons mentioned above. To some of these insecticides can be added a fungicide in a colloidal or a readily miscible form, such as colloidal sulphur, so as to provide a combined insecticide and fungicide, such as that recommended for use on young citrus and mango trees.

These ready-made concentrated insecticides and fungicides are sometimes more expensive than similar home-made preparations, but on the other hand they have many advantages over the home-made article. They are standard and uniform as regards poison content, they are easily mixed with cold water to the required dilution and they usually have better wetting and spreading qualities, thus insuring a more effective control of pests and diseases. Moreover, they can be applied to tender foliage without risk of burning, provided that the recommended proportions are used and that spraying is not done during the heat of the day.

A reference to the insecticidal measures recommended above under the various pests will indicate that for all ordinary purposes it should be necessary to keep in stock only three insecticides, namely nicotine sulphate, soap and lead arsenate. A fish-oil-resin soap may be necessary for hard scales and mealy-bugs on old trees. The nicotine-soap solution will control not only such pests as leaf-miner, aphids, mango leaf-hoppers and soft scales, such as green bug, but small caterpillars as well, such as leaf-roller and small Papilio larvae. For larger caterpillars, leaf-eating beetles and the two mango weevils, it is advisable to apply lead arsenate, especially as a protective measure in places where such pests are known to be prevalent. Lead arsenate is also the essential ingredient for poisoned-baits for fruit-fly, etc.

Spraying machines.—As regards spraying equipment, this is now manufactured so efficiently and for so wide a range of uses, that it is possible to get machines for practically all spraying requirements. For instance, an ordinary hand sprayer or atomiser is quite suitable for a few small trees during the first two or three years after planting. Then for small orchards a bucket pump or a pneumatic knapsack-sprayer becomes advisable, with an extra length of hose and an extension rod with an angle bend for moderate sized trees. For larger orchards of trees coming into bearing something more powerful is required, such as a mounted barrel-sprayer or a hand-power machine with a powerful pump.

The proper maintenance of spraying equipment is essential if effective control work is to be done. The machines should be kept clean and in good working order, and spare parts, such as extra leather washers, nozzles, and rubber hose, are certainly required if serious breakdowns are to be avoided.

Application of sprays.—Since the main object of spraying is to control the pest or pests which may be present on any tree or group of trees, it is essential that the insecticidal mixture should be applied in the most efficient manner possible. For the control of many leaf-eating insects, the poison should be applied so as to cover both sides of all the leaves with the object of giving the insects a fatal dose if they attempt to feed. For sucking insects, effective control can be attained only if the insects are thoroughly wet with the spray fluid, so that they are killed by suffocation, by paralysis of their nerve centres, etc.

The attention of fruit-growers is directed to *The Tropical Agriculturist* for May, 1935, Departmental Notes, "Some Notes on Spraying against Plant Pests and Diseases," pp. 304–309. For advice on the control of any unusual fruit-tree pests application should be made direct to the Entomologist, Peradeniya.

Note.—With regard to the control measures recommended for citrus fruit-flies in the first part of these notes (*The Tropical Agriculturist*, April 1936, p. 196), special mention should have been made of the bagging of grape fruit, a note on which appeared in the *The Tropical Agriculturist*, February 1936, pp. 100, 101. This should prove a valuable way of preventing attacks on citrus fruits by citrus canker and fruit-fly, especially in small areas, where it may supersede the use of poisoned baits.

Since these notes were written an investigation into the local parasites of fruit-flies has been started in connexion with the visit of Mr. F. C. Hadden, an Entomologist attached to the United States Bureau of Entomology. Mr. Hadden has been touring Eastern countries in search of parasites which may be useful against the Mediterranean fruit-fly and the melon fruit-fly in Hawaii. The bionomics of our local fruit-flies will also be studied in greater detail.

THE AGRICULTURAL DEVELOPMENT OF THE DRY ZONE OF CEYLON

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PRINCIPAL, FARM SCHOOL AND OFFICER-IN-CHARGE, SCHOOL FARM AND EXPERIMENT STATION, PERADENIYA

THE problem of the progressive agricultural development of the dry zone of Ceylon is one whose successful solution will have the following important results: (i) the improvement of the economic and physical condition of the existing villagers, (ii) the utilisation of large areas of uncultivated land to produce sufficient foodstuffs to render Ceylon self-supporting, and (iii) the provision of land for the normal expansion of population. The successful attainment of these three results is so obviously of paramount importance to the well-being of the Island that a discussion of the problem is desirable no matter what the merits or demerits of the suggestions made in this paper may be. In a problem so involved as this no simple cut-and-dried solution is possible and any suggestions made will almost certainly need modifying or changing in the light of further experience.

The dry zone of Ceylon may somewhat loosely be defined as that part of the Island where the annual rainfall is less than 75 inches and where the growing of swamp rice by direct rainfall, unsupplemented by irrigation water, is either precarious or impossible. To agriculturists in other countries areas receiving an annual precipitation of even 50 inches would hardly be termed " dry " and it must be explained that the dry zone of Ceylon receives the greater part of its rainfall during the north-east monsoon from October to April. During the south-west monsoon the precipitation is generally less than 20 inches and in the N.W. and S.E. corners of the Island less than 10 inches. The following table gives the average rainfall during October-March and April-September in representative places in the dry zone. The meteorological records give the south west monsoon as prevailing from May to September inclusive, but is considered to be agriculturally more useful to give rainfall figures for the period April to September as dry season crops are generally sown in April.

MEAN RAINFALL IN INCHES

Place	*October-March*	*April-September*
Jaffna	40·25	9·62
Mannar	31·34	7·62
Anuradhapura	37·50	17·76
Trincomalee	46·99	16·52
Topawewa	41·05	13·94
Batticaloa	53·42	10·83
Hambantota	24·39	14·85
Maho	38·45	22·58
Maha Oya	58·36	24·30
Bibile	63·50	18·53

The last two places do not strictly come within the above definition of "dry zone" as their total rainfall exceeds 75 inches. They are representative, however, of a large tract of land in the lower areas of the Province of Uva and a wedge of land in the Eastern Province, at present largely uncultivated but particularly suitable for development in the same way as the dry zone proper.

The dry zone as defined above includes all the low-country of Ceylon (land mainly below 500 feet above sea level), with the exception of the low-country in the south-west lying roughly between Kurunegala and Matara, and extends to well over half the area of the Island. It forms a belt between the foothills of the central mountainous region and the sea whose width varies from about 120 miles in the north to about 40 miles in the south. The dry zone includes the Northern and North-Central Provinces, part of the North-Western and Southern Provinces, the low-country of Uva and the whole of the Eastern Province.

Except in the thickly populated Jaffna peninsula and along the sea-board of part of the Eastern Province cultivation in the dry zone consists essentially of scattered blocks of paddy land, generally under large or small-sized irrigation tanks, surrounded by large areas of jungle or scrub jungle a small fraction of which is cultivated annually on what is known as the *chena* or shifting system of cultivation. There is a certain amount of garden cultivation in and near villages and a comparatively small amount of intensive cultivation in the dry season

of chillies and tobacco irrigated by hand from wells and, chiefly, rivers. The intensive cultivation of the Jaffna peninsula will not be discussed here as little land is left for development. The garden cultivation previously mentioned might conveniently include land near villages regularly cultivated with cassava.

Essentially the characteristics of the dry zone are a scattered cultivation, large areas of primary and secondary jungle and scrub jungle and a sparse population with, except under tanks, a low and precarious *per capita* production. The agricultural practices have been formed by generations of painful experience and are generally the best possible under existing conditions. It is all too easy to condemn the *chena* system of cultivation which is universally described as wasteful, but condemnation must be accompanied by practical proposals for a permanent system which will maintain the land in a high state of fertility, will keep weeds under control, and provide a reasonable market for the crops grown.

The shifting or *chena* system of cultivation is met with in most parts of the tropics where there is more land than is immediately necessary for the population. *Chena* cultivation consists essentially in felling and burning primary or secondary jungle during the dry season and broadcasting seeds at the beginning of the rains in the loose top soil and ashes. The tallest available jungle is chosen ; where land is scarce low secondary jungle is used but primary jungle is preferred. Successful cultivation depends upon having sufficient jungle-growth and on getting a good burn. A good burn depends to some extent on skilful felling of the trees and largely on suitable weather conditions. In Ceylon a *chena* is generally cultivated for two seasons, the first season with kurakkan, maize, rice, chillies and vegetables and the second season with gingelly. In Ceylon where *chena* permits are given a family will generally cultivate about an acre. The advantages of the *chena* to a villager include the following : (a) little equipment and no cattle are required, (*b*) the accumulated fertility of a varying number of years is utilised for the crop, and (*c*) weeds are almost entirely absent during the first season.

The *chena* system is undoubtedly wasteful of timber and land, but it dies a natural death when the population increases sufficiently. In some places the noxious weed *illuk* or *lalang* (*Imperata arundinacea*) succeeds the crops taken on a *chena*

and the natural regeneration of the jungle is greatly retarded or even prevented. A harmful result of widespread and continued *chena* cultivation is the effect on climate. This effect is not known precisely, but there is no doubt that the destruction of large areas of high jungle will bring about a drier climate. If it is assumed that chena land regenerates sufficient jungle for re-cleaning in ten years the total area of jungle necessary for a yearly *chena* of 1 acre is 10 acres. If a permanent system of cultivation can be devised on 5 acres of land the saving of jungle will be considerable. The end of the *chena* system can be hastened by providing larger areas of irrigated rice land, or by evolving a system of permanent cropping by which the fertility of the land can be maintained at a high level and weeds kept under control. Such a system will call for implements and cattle and will involve the provision of sufficient credit facilities to enable the cultivator to obtain these. Until the villager can be demonstrated an economic system of permanent cropping and be furnished with sufficient credit for implements and live-stock the arbitrary abolition of *chena* permits will mean hardship and even starvation to the many who at present rely on *chena* cultivation for their livelihood.

The dry zone can be developed by (i) increasing the existing irrigation facilities and (ii) evolving a practical system of permanent dry land cultivation. The first method undoubtedly presents the most immediately attractive prospects for several reasons. The crop grown on the irrigable land will be rice, the production of which in Ceylon is at present about one-third of the requirements. There is, therefore, a large potential market for the rice that can be produced from an additional million and a half acres of paddy land and there is no reason why the rice produced, if milled in a modern type of mill such as that recently erected by the Department of Agriculture at Anuradhapura, should not meet the quality requirements of the market. Moreover, rice cultivation is familiar to and extremely popular with the villager and the equipment necessary for cultivation is simple and comparatively easy to obtain. Finally, rice in the husk can be stored with little risk until a buyer is found ; the grower is not forced to sell to the first bidder by fear of losing his produce as may happen with perishable crops like vegetables and root crops.

The provision of increased irrigation facilities is a matter for, and the energetic policy of, the Irrigation Department. At present many of the thousands of small village tanks are being restored and new tanks are being constructed. Recently the Director of Irrigation has announced that work is being started which will eventually involve the storage of all the rain which falls in the dry zone. It is the hope of many cultivators that ultimately ways will be found of using in the dry zone some of the water which is carried from the mountainous regions of the Island by, for example, a river like the Mahaweliganga.

The second method of developing the dry zone is the organization of a permanent system of agriculture on unirrigated land and it is now proposed to discuss this in detail.

The maintenance of soil fertility at a sufficiently high level to produce remunerative crops is particularly difficult under tropical conditions where solar radiation is responsible not only for an extremely rapid rate of humus decomposition but also, it is believed, for the direct loss of nitrogen. Corbett* has recently drawn attention to the fact that "the nitrogen and organic matter of the soil varies inversely with the soil temperature and the amount of solar radiation received. At temperatures below 25°C (77°F) there is an accumulation of organic matter in the soil, but at temperatures about this humus decomposition outpaces its formation." Vageler† states that "The widely held view of native cultivators in the Dutch East Indies that felling of tree cover for a period of three years, combined with exposure of the soil, is enough to destroy the richest bed of humus is precisely what one would expect from such a procedure. It is unfortunately true that even now unreflecting introduction of European practices in the matter of bare fallow occasions much damage in many tropical regions." Loss of fertility together with a large increase of weed growth make the *chena* cultivator seek new jungle for clearing after a year or two. It has recently been found in the United States that nitrate-producing organisms are rendered inactive or destroyed by exposure to sunlight, damage which, like the destruction of humus, will undoubtedly be hastened by the

**Biological Processes in Tropical Soils.* Steven Corbett, W. Heffer & Sons, Ltd., Cambridge, 1935.

†*An Introduction to Tropical Soils.* P. Vageler. *Macmillan & Co., Ltd.*, 1933.

mechanical disturbance of the soil inevitable in any permanent cultivation of annual crops. Without a definite system of fertilizing the soil the cultivation of crops will be unremunerative. An examination of the yields obtained at the dry zone experiment stations in Ceylon for the period 1932 to 1934 shows that, even after making allowance for unusual weather conditions, they are generally well below what are considered good yields in India.

For villagers with little or no credit to buy artificial fertilizers, even if their use so far away from the source of supply should prove economic, the maintenance of the fertility of the soil must depend either on cattle manure, compost or green manure. A system of permanent cropping involves the use of cattle so cattle manure will be available but almost certainly in insufficient amount and it would appear advisable to use what is available for turning into compost along with any green vegetable material than can be obtained. Some simple modification of the Indore method of compost making is within the capability of the villager. It must be remembered, however, that the coconut black beetle breeds in decaying vegetable matter and where the heat generated in the compost heaps is insufficient to kill the larvae or to deter the beetle from laying eggs it will be necessary to turn the heaps and kill the larvae at suitable intervals. The making of compost, although for centuries a fundamental part of Chinese and Japanese agricultural practice, will take time to become popular with the Ceylon villager and where the holding is comparatively large as it would be in Ceylon the fertility can more usefully and easily be maintained by the growth, *in situ*, of green manures, leaving the cattle manure and compost for a small garden of fruit trees and vegetables, and for the patch of fodder grass. The use of green manuring in maintaining fertility in Nigeria is described by Faulkner and Mackie in a book* which is of particular interest to Ceylon. The system in use at Ibadan which produces good crops year after year is to grow *in situ* a green manure in between each crop. Experiments have shown that this system of manuring is successful in maintaining the soil in a sufficiently high state of fertility and it is even thought that the green manuring need not be so frequent. The authors state

**West African Agriculture*, D. T. Faulkner and J. R. Mackie, *Cambridge University Press*, 1933.

that ' . . . green manuring is generally regarded as being in the nature of a permanent improvement of the soil, the benefit of which will be seen for many years. Our experience is exactly the contrary ; it seems to be rather of the nature of a quick-acting manure, of which the full benefit is obtained, and the effect fully exhausted in at most two succeeding crops.' It was found that the treatment of the green manure had little effect on the succeeding crop whose yield was the same if the green manure was cut green and allowed to decompose gradually before burial, if the green manure was allowed to grow until it died of drought before burying or even if it were burnt *in situ*. The only treatment which had an adverse effect was the removal of the green manure from the land and merely ploughing in the stubble. Although chemical investigations appeared to show that the green manure should be cut and buried green practical yield trials did not confirm this.

Any green manure grown requires incorporating with the soil and for this purpose a plough that will invert the furrow is necessary. The " Ceres " plough is recommended and can be pulled by good village cattle providing the cattle are not worked for too long at a time and are well fed, but the cost of the plough (about Rs. 35·00) is comparatively high. Shift can be made with a " Meston " plough which costs just under Rs. 5·00 for the ironwork but this plough does not completely invert the furrow. If imported in bulk the price of the " Ceres " plough could be appreciably reduced. It has been found at the Experiment Station, Peradeniya, that the best way of dealing with a green manure crop is to cut the standing crop into lengths of six to nine inches and to plough in after a few days. A green manure like *Crotalaria anagyroides* when grown under favourable conditions produces a stem whose lower portion is woody and it is convenient to remove these woody stems (without cutting) from the field before ploughing. Whether a green manure crop can successfully be grown depends chiefly on the rainfall during the growing season. In the dry zone there is invariably sufficient rain during the season from October to March (generally known as the *maha* season); from April to September (generally known as the *yala* season) the rainfall is low, but except in the extreme north and in some places on the east coast about 15 inches to 18 inches of rain can be expected. During the *yala* season gingelly (*Sesamum indicum*)

is grown in many parts of the dry zone and it is probable that a quick-growing green manure like *Crotalaria juncea* or dhaincha (*Sesbania cannabina*) could also be grown. Green manures worthy of a trial for *maha* are *Crotalaria anagyroides*, *Crotalaria usaramoensis*, *Crotalaria juncea* and *Sesbania cannabina*, the first two sown at 10 to 15 lb. per acre and the last two at 15 to 20 lb. For *yala* the last two are recommended.

The control of weeds presents a difficult problem in Ceylon. It is probable that all crops (except the green manures) will have to be grown in drills to permit of weeding by hand or by a simple form of cultivator like the Burmese Harrow. Seed can easily and successfully be drilled by the Indian seed drill, an implement which can cheaply be made by the village carpenter. In the permanent system of cropping here advocated the land will be cultivated every season alternately with crops and green manures. The crops will be weeded and the green manures will, to some extent at least, smother the weeds. Where conditions are suitable for a luxuriant growth of the green manure (especially if this be *Crotalaria anagyroides*) the smothering effect will be great.

Where sloping land (even land on a slight slope) is cropped annually precautions will have to be taken to prevent soil erosion. The intensity of the rainfall in the dry zone is frequently such as will cause serious soil wash and a successful farming system entails the conservation of the soil itself as well as of its fertility. The large amount of soil wash on moderately sloping, cropped land in the dry zone is not generally realised; the prevention of soil wash may make all the difference between success and failure. Anti-soil erosion measures should (i) prevent by means of drains run-off from adjoining areas entering the land and (ii) restrict or prevent the flow of water which falls on the land in the shape of rain. The latter problem is solved in parts of Africa by the construction of contour ridges or bunds and a similar method would appear most suitable in Ceylon. It is suggested that small contour bunds be constructed about 15 inches broad and 6 to 8 inches high (after consolidation) from the earth provided by a series of disconnected silt pits which should run alongside the bund. If the bund is below the silt pits these will provide storage places for some of the excess rainfall as well as soil for the bund. The distance apart of the

bunds will depend on the slope of the land, the type of soil and the rainfall. If the land between bunds is ploughed along the contour there is no reason why the bunds should not be more or less permanent structures. Erosion of the bunds would be lessened by allowing grass to grow on them or, better, by planting a ground cover like *Indigofera endecaphylla*.

The choice of crops for the permanent cropping advocated is governed to some extent by climatic conditions and largely by the market demand. Crops such as kurakkan, yellow maize, chillies, cassava, pumpkins and dry-land rice can be grown for the cultivator's own use. Crops grown for sale must be assured of a satisfactory market. Maize is one of the most successful crops in the dry zone ; not only does it suit the climatic conditions, but it grows above weeds that might smother a crop like kurakkan. Unfortunately, however, the present demand for maize is small and little extension of the demand can be anticipated unless outside markets are found or the dietary habits of the people are modified. Gingelly and perhaps green gram are probably the most suitable crops for the *yala* season and a good market should readily be found. Cotton is satisfactory for *maha* provided the distance it has to be carted to the railway is not too great and provided also the arrangements made by the Department of Agriculture for marketing the seed cotton are continued. The bulk of the chillie crop will have to be dried as there is only a small demand for green chillies. At present there is an unsatisfactory market for dried chillies, due, it is thought, to the small amount available. In some localities tobacco is a suitable crop, but any increased production will have to be of a light flue-cured variety such as Harrison's Special suitable for the manufacture of cigarettes. In regions of heavier rainfall ginger, turmeric and Dioscorea yams can be grown. It is advisable that all crops which are grown should be capable of being stored without loss for several months if the cultivator is not to be at the mercy of the trader. One crop which can be stored and for which there is a large demand is rice and it is desirable to investigate thoroughly the possibility of growing dry-land rice. During the *maha* season of 1935-36 a plot of 1·8 acres on the Experiment Station, Peradeniya, was cultivated with dry-land rice. The soil was in poor heart and the previous crop of cow peas grew badly and was ploughed in. A dry zone swamp rice selection (*Vellai illankalayan*, 28061)

was broadcast at the rate of 2 bushels per acre along with 1 cwt. Nicifos No. 2 per acre. The crop was weeded once and matured in 4½ months. In spite of a partial drought in January and February the yield of winnowed paddy was 24·86 bushels per acre, an extremely promising yield under the conditions of the trial. The rainfall during the growing period was 38 inches.

To supply food for the plough bulls and milk cows maintained by the cultivator it will almost certainly be wiser for him to grow fodder crops rather than to rely on what poor communal pasture there may be. Jowar (*Sorghum vulgare*) is grown as a cattle fodder in India. It is made into hay and fed after being cut into short pieces by a knife or a chaff-cutter and generally moistened with water in which a little poonac has been soaked. A very useful fodder which can be cut and fed green when required is Napier or Elephant grass. Under suitable conditions Napier grass will yield as much as 100 tons of green fodder per acre in a year. Although in some parts of the dry zone the rainfall during the dry season may be barely adequate for the successful cultivation of this grass it is well worth widespread trial.

The suggested size of a permanently cultivated dry zone holding is about five acres. This is considerably smaller than has previously been recommended, but the writer believes that moderately intensive cultivation stands the best chance of success. Unless crops are grown on soil kept in a high state of fertility (by green manuring) their growth will be so poor that they will not cover the ground which will then be exposed to the disastrous effects of prolonged solar radiation. Unless crops are weeded they will be smothered by weeds. Successful cultivation, therefore, would appear to be possible only on a comparatively small holding. The live-stock on a typical holding, therefore, might well consist of one pair of working bulls, two milk cows to supply the milk and ghee so essential in the villager's dietary and to supply young stock for replenishing or sale. Implements would include a mould-board plough with spare parts, a Burmese Harrow, an Indian seed drill and a few hand tools. Credit facilities will therefore be necessary to enable the cultivator to obtain the requisite equipment.

Whether co-operative credit societies with some Government assistance can finance cultivators must be left to others to determine.

In the same way market facilities are almost equally necessary, for the cultivator will have to sell part of his crops to obtain money for the necessities of life which he cannot produce himself, for the repayment of loans and for the payment of interest on loans. It is hoped that co-operation between the Department of Agriculture and the Marketing Commissioner will in time provide the necessary markets. The market problem is only briefly mentioned here ; it is one which bristles with difficulties and to which a solution must be found before permanent cropping can successfully be established.

It is not possible without continued experiment to lay down a hard and fast sequence of cropping, and even after experiment the sequence will be elastic and respond to price changes. The following diagram gives a suggested sequence of cropping which is intended not as a model but as a suggestion to be modified and improved. Of the 5 acre holding it is assumed that $\frac{3}{4}$ acre would be occupied by the buildings and garden and $\frac{3}{4}$ acre by Napier grass or other fodder crop.

SEQUENCE OF CROPPING ON 3¼ ACRES

Year	*Season*	½ *acre*	½ *acre*	½ *acre*	½ *acre*	½ *acre*	½ *acre*	½ *acre*
First	Maha	Rice or Kurakkan or Maize		Cotton		Chillies or Pumpkins	Green Manure	
	Yala	Green Manure					Gingelly or Green Gram	
Second	Maha	Cotton		Chillies or Pumpkins	Rice or Kurakkan or Maize		Green Manure	
	Yala	Green Manure					Green Gram or Gingelly	

In districts of suitable rainfall tobacco might take the place of cotton, and Dioscorea yams, turmeric and ginger be included in the rotation. Manioc (cassava) will grow in most parts of the dry zone and where there is a local demand a small area could be cultivated with this crop. Sweet potatoes can be included as a maha crop where there is a demand, but at least a small patch should invariably be grown for the use of the cultivator and his family. There are numerous varieties of sweet potatoes and trials are being carried out at Peradeniya. Gandia is a variety which had done well over a period of years and lately a Russian variety, N219, has shown considerable promise. It matures at Peradeniya in about five months while Gandia takes about six. It is generally thought that sweet potatoes cannot be stored for more than a week or two, but experiments at Trinidad have shown that when stored in a pit lined with straw and covered with earth the tubers will keep without undue shrinkage for about two months. They also kept well when stored in bags, but there was more shrinkage. It should be mentioned here that where maize is grown the yellow variety is preferable owing to its greater vitamin A content.

An essential part of a dry zone holding will be the home garden, a plot of land, say, of about three-quarters of an acre devoted to fruit-trees and vegetables. Fruit-trees should include mango, lime, orange, pomegranate, plantains and papaw. Other trees which are invaluable are coconuts, jak and bread-fruit. Drum sticks (*Moringa pterygosperma*) not only supply a vegetable but are useful as live fence posts.

Grape fruit flourishes in the wetter parts of the dry zone such as Bibile, but its successful cultivation as a money crop involves considerable care and attention. The trees must be regularly sprayed to guard against citrus canker, mildew and leaf-miner, and it will almost certainly be necessary to bag the fruit in grease-proof paper bags to prevent damage by fruit-fly. The sale of damaged fruits would rapidly destroy the local demand and it is unlikely that grape fruit will be a suitable village crop in the near future. The system of farming here

advocated which entails the keeping of one or two milk cows and the growing of fruit and vegetables in a home garden should supply the cultivator and his family with a complete diet containing the necessary vitamins, and their health should improve rapidly.

To bring this system into being on a large scale will necessitate in the first place extended trials at different dry zone experiment stations and the probable modification of the sequence of cropping suggested. Only after extended trials and demonstration can the system be recommended to cultivators with a reasonable hope of overcoming their engrained and what are, after all, natural prejudices.

A NOTE ON THE EFFECT OF SOWING DATE ON THE AGE OF PADDY

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IN *The Tropical Agriculturist* for June, 1931 (LXXVI. 6, 1931, p. 331) Lord and de Silva recorded the results of an experiment which tested the results of sowing a *maha* paddy at monthly intervals throughout the year. They found that sowing in the month normally chosen by the villager, and in the months immediately following, gave good results, but sowing at any other time produced plants which did not flower at all or yielded only empty grains. The experiment has been repeated over a period of two years, and has been carried out with both *maha* and *yala* varieties.

In June, 1933, two small plots were sown, one *mawi* B-11 and the other with *heenati* I-CPY-15. *Mawi* B-11 is the pure line paddy recommended for cultivation in the Central Province during the *maha* season ; it is usually sown in August and matures in $6\frac{1}{2}$ months. *Heenati* I-CPY-15 is the corresponding pure line for the *yala* season, is sown in March and requires $4\frac{1}{2}$ months to reach maturity. A plot of each variety was sown at monthly intervals for two years, until May, 1935, and records were taken of flowering and maturity dates, and yield of grain produced.

The results are given in detail in Table I. and are represented graphically in Figs. I. and II. It will be seen from the table and from Fig. I, that the results obtained by Lord and de Silva have in general been reproduced. Sowing in August or September gives a crop of normal age and yield, but at any other time the age is considerably increased, and the yield reduced or destroyed by empty grains. In those plots in which a crop was obtained the plants had delayed flowering and

maturity until approximately the month in which they would have flowered had they been sown at the proper time.

The results with the *yala* paddy are not consistent, and, indeed are not what might have been expected. The monsoon periods in Ceylon are approximately October to mid-December (*maha* or N.E.) and May-July (*yala* or S.W.), yet those plants which flowered during the dry months of August and September failed to set seed, whereas those flowering in the monsoon months of November and May gave crops, and were moreover of normal age. It is possible that the dry conditions of 1934-35 are partly responsible. It appears from the table that it is unsafe to sow a $4\frac{1}{2}$ month paddy after March for the *yala* season, but that it may profitably be sown in October or November as a short-aged *maha* crop. This is common knowledge among villagers, who, having through illness or lack of sufficient rain been prevented from sowing their normal *maha* crop, will sow a shorter-aged crop at a later date. It also appears that a crop may be obtained by sowing in any month of the year, provided that the correct variety be chosen.

These results raise again the interesting question, discussed in a review in a recent number of this journal, as to what is responsible for differences in rates of development of plants in tropical countries.

TABLE I

Sown in	Mawi B-11 *Flowered in days*	Mawi B-11 *Harvested in days*	Mawi B-11 *Yield in oz.*	Heenati I-CPY-15 *Flowered in days*	Heenati I-CPY-15 *Harvested in days*	Heenati I-CPY-15 *Yield in oz.*
January ..	Dec. 344	Jan. 386	—	Mar. 83	May 127	1
February ..	Dec. 312	Jan. 355	—	May 95	June 141	5
March	Jan. 300	Feb. 350	2	June 99	Aug. 153	5·5
April	Dec. 256	Mar. 336	9	Aug. 132	Oct. 179	—
May	Dec. 232	Feb. 290	8	Sept. 125	Oct. 170	2
June	Dec. 190	Feb. 252	8	Sept. 95	Oct. 140	—
July	Dec. 173	Feb. 220	12	Oct. 90	Nov. 140	—
August ..	Jan. 159	Feb. 196	13	Nov. 94	Jan. 146	9·5
September ..	Jan. 141	Mar. 191	16·5	Dec. 88	Feb. 148	2·5
October ..	April 197	June 247	4	Jan. 102	Mar. 144	13
November ..	Aug. 276	Sept. 325	—	Feb. 88	Mar. 130	13
December ..	Nov. 343	Jan. 394	—	Mar. 90	April 142	3

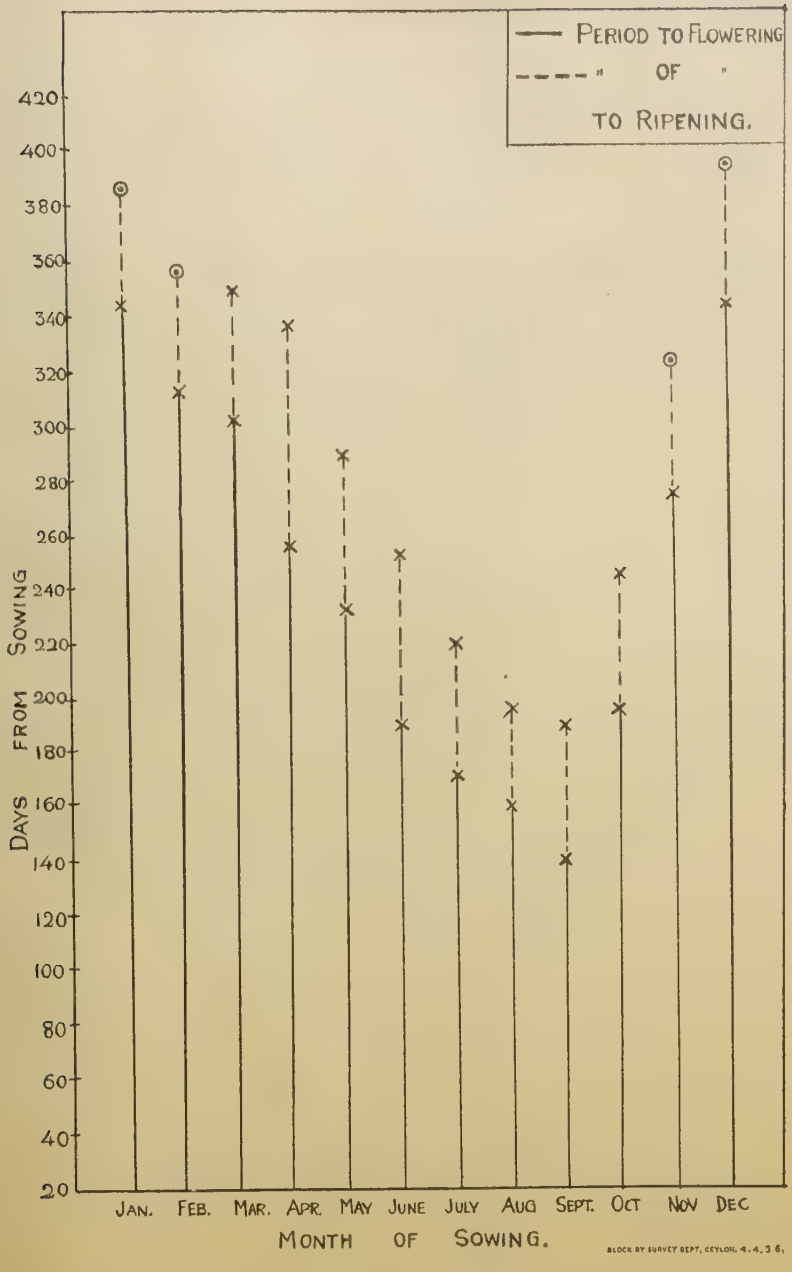

FIG. I.—MAHA. A CIRCLE INDICATES NO CROP

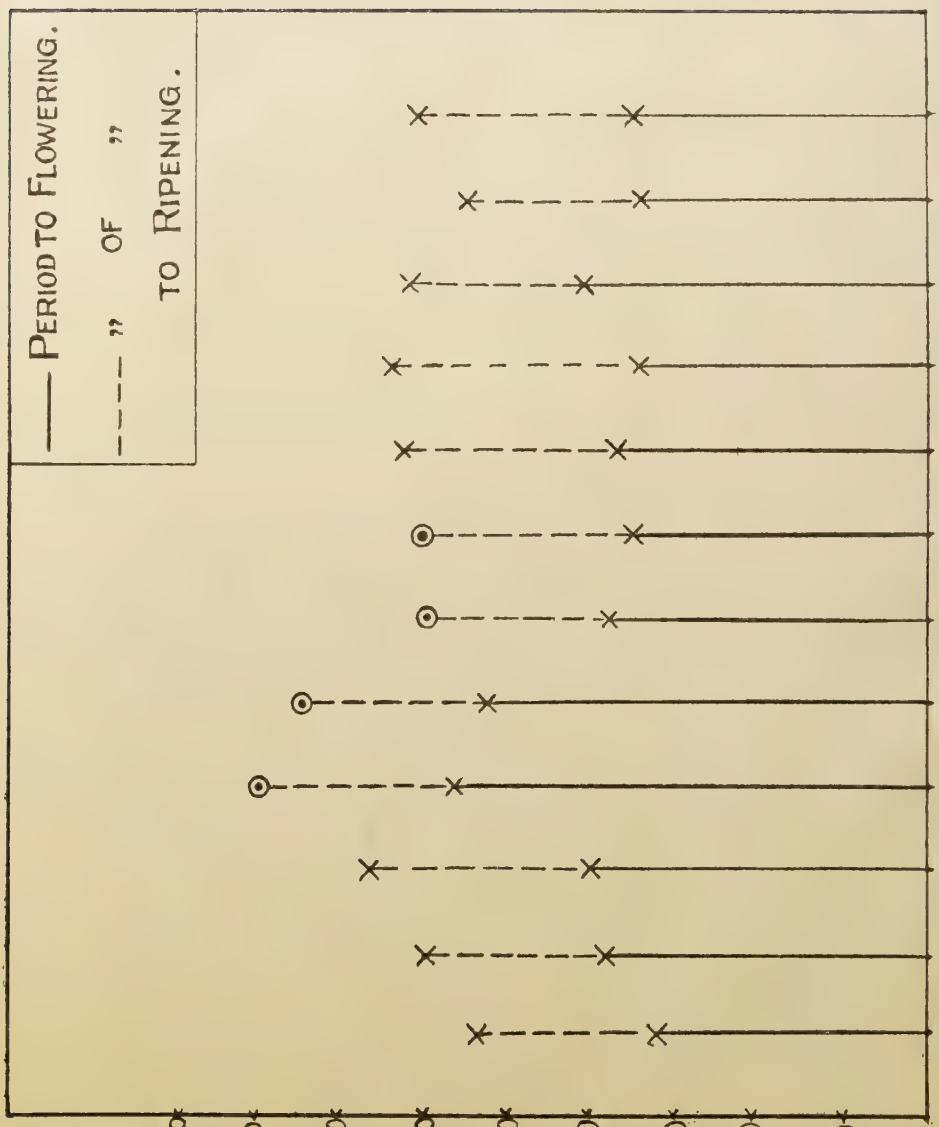

FIG. II.—YALA. A CIRCLE INDICATES NO CROP

THE GROWING OF CABBAGES IN THE JAFFNA PENINSULA

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THE first trials with these vegetables which ordinarily grow in temperate climates and which have hitherto been grown in Ceylon only on the hills were made in the Experiment Station, Jaffna, in 1924. The work has been continued up to the present.

The aim of the management from the beginning was to test the possibility of growing cabbages on an economic scale to be adopted by the village farmers as a money crop. Observations were made and valuable experience gained with regard to the time of sowing, preparation of the seed bed, watering, transplanting, spacing, preparatory cultivation, suitable manures, after cultivation irrigation, etc.

Since 1930 a progressively growing number of farmers have been encouraged to grow this crop on a commercial scale, and with its increasing popularity here is a demand for information with regard to the most suitable varieties and the proper method of cultivation. This article is intended to meet this demand.

The Cape cabbage has given the best results. There are several types of this which thrive equally well under the same conditions and can be grouped into early and late varieties. Early varieties take 80 to 100 days to mature while late varieties 100-120 days. Of the types tested the best were (1) Cape Largest Solid Drum Head—this variety withstands heat and sun admirably well. It produces a high percentage of uniform good quality heads. (2) Cape Early Drum Head—this is a flat headed variety and has an abundance of wrapper leaf of deep green colour. (3) Cape Early Sugar Loaf—it is a medium sized variety with pointed heads, slightly lighter in colour than Cape Early Drum Head.

SELECTION OF SEED

The seed cannot be matured satisfactorily under local conditions. Imported seed should be secured for each season.

It is specially necessary that good seed with a reputation for a high percentage of germination be obtained from a reliable seedsman.

METHOD OF GROWING PLANTS ON SEED BEDS

The season for sowing cabbage is from the latter half of August to the middle of October. It is a good practice to make three sowings say one by the 25th of August, one about the 15th of September and one by the beginning of October. The first and second sowings can be done in well prepared beds as there will be less damage by rain, but for the third sowing boxes should be used to save loss from heavy rains. A bed of $5' \times 30'$ should give ample plants for an acre. The third sowing is the most important for a strong plant is required for late planting. When the plants are about four weeks old in the boxes they should be transferred to a bed richly manured before they are set out in the field. These will head quickly and will be ready before the dry weather sets in. The first and second sowing need not be pricked out from the seed bed but may be taken direct therefrom to the field. The seed beds should not be as rich as the place where they are to finish their course. The seed should be sown in the beds rather thinly either broadcast or in the drills which may be about two inches apart and covered with an inch of soil.

Plants grown in drills are harder and much easier to lift and transplant. The soil should be of friable sandy loam free from stones and should receive an application of well rotted manure and leaf mould. After sowing the seeds the beds are covered with dried plantain leaves to hasten germination ; after the seeds have germinated the plantain leaf covering is replaced by twigs of some shrubby growth known locally as " Manthu " which protects the young seedlings from the hot sun. It is not necessary to remove this cover of the bed to water it as it could be thoroughly watered with a watering can with a fine rose. When the seedlings are well up they should be exposed to the sun for a short time in the morning. The period of exposure should be gradually increased and when they are sufficiently hardened the covering is no longer necessary. The seedlings will be ready for transplanting when they are 4 to 5 weeks old. It is necessary to water the beds copiously at the initial stages to keep the surface moist in order to facilitate the germination of seed ; later on the quantity of water should be reduced. The object of watering the seed bed is to keep it moist but not wet.

TIME OF PLANTING

If the bed is started about the 25th of August the plants should be ready for transplanting by the 15th October, with the initial rains of the North-East monsoon. The greater part of the rain falls between October and the first half of December. A large portion of this moisture is available for the early growth of the crop. The rainfall diminishes during the latter half of December and a dewy weather sets in and lasts till the middle of March. During this period occasionally light showers are received which tend to maintain the temperature of the soil and the air moderately cool which is a requirement to promote the development of heads of good quality. Cabbage must have an adequate supply of moisture throughout the growing season. An excessive amount of water in the soil is however not desirable and too much fluctuation of soil moisture may cause the production of loose and small heads.

Cabbage is grown successfully in a wide variety of soil types ranging from clay loams to sandy loams, but it grows to perfection on fertile loams rich in organic matter. For late crops which mature during dry weather, the heavier types of soil should be used for they hold more moisture and are cooler. The lighter and well drained soils may be employed to produce the crop that is planted early and grown during the cool season.

PREPARATION OF THE LAND BEFORE PLANTING

It must be remembered that the soil should be in a high state of fertility if a satisfactory growth of cabbage is to be obtained. The land should be thoroughly prepared before setting out the plants in the field. Thorough preparation of the land enables the plants to establish quicker and grow uniformly. When cabbages follow tobacco, dry ploughing is done in March or April cattle ponning is done from July to October. The land is again ploughed and cross ploughed in October after the rains to cover the droppings and mix it with the soil. The burying of green leaf is done after the last ploughing which in addition to increasing the humus and nitrogen content of the soil assists in conserving the moisture in the soil at a uniform depth. Well decomposed cattle manure is applied at the rate of 16 carts per acre and covered with mammotties while levelling. The ground is then ready for planting.

TRANSPLANTING

When the plants have put out six to eight leaves they are ready for transplanting. Strong vigorous plants only

should be selected for transplanting. Just before removal the beds from which the plants are to be taken should be thoroughly watered so as to soften the soil and to allow the seedlings being removed with a ball of earth attached to them. The rows should be marked out two feet apart and the plants set out 1½ feet in the rows. Transplanting is done by the same method as for other plants, that is, either a wooden pin bluntly sharpened or the fingers are used for making the hole into which the plant is placed and the soil is then pressed around the rootlets. Planting should be done late in the evening. The plants should be shaded and pot watered immediately after planting. The crop should be pot watered every morning in the absence of rain for about three weeks.

AFTER CULTIVATION

The crop requires clean cultivation and unremitting care. As soon as the plants have started growing stir the ground around them and give frequent clean cultivation.

In addition to green leaf and cattle manure the use of inorganic nitrogenous fertilizers is necessary to keep the soil in a state of high productivity. Generally, lack of nitrogen is what usually limits the growth of cabbage. Nitrogen can be applied in the inorganic form as nitrate of soda, sulphate of ammonia or Nicifos. The fertilizer may be applied after the first hoeing which is usually done three to four weeks after planting and until a month before harvest. The first application is done round the plants after the first hoeing at the rate of 100 to 120 lb. an acre. The second application of 150 lb. to 200 lb. is done after the second hoeing and the formation of beds and channels for irrigation, which is usually done about seven weeks after planting. After the beds and channels have been formed for irrigation further cultivation is not necessary and even beneficial except the removal of weeds which rob the soil of moisture and soil nutrients. The beds for irrigation are formed with the soil drawn towards the plants so that the water may stand at a distance from the base. The soil at the base of the plant is always kept loose which facilitates aeration and better stand is obtained. The crop is usually irrigated once in three days but the frequency of irrigation depends on weather and soil conditions. It takes some experience to know when to irrigate but as a rule the plants are in demand of water when they become dark green

and the leaves look and feel leathery. When there is plentiful supply of moisture the leaves are brittle and are of a lighter green.

PESTS AND THEIR CONTROL

Serious damage is done to the crop by grasshoppers and caterpillars. The most serious injury is done by caterpillars to the terminal bud which hinders the formation of new leaves. The most destructive period is the rainy weather when the greatest number of the larvae are present. Control of these can be effected by spraying with a mixture made of 3 lb. of McDougal's lead arsenate to 100 gallons of water alternated with nicotine sulphate, spraying strength being 1 oz. to 2 gallons of water. These insecticides in amounts used have been found not poisonous to human beings and can be used without danger. On the beds ashes should be sprinkled over the young plants to prevent them being damaged by insects.

HARVESTING AND YIELD

Harvesting should not take place until the heads are hard. Inexperienced cultivators have a tendency at times to harvest cabbage too soon especially if prices are high. Immature heads wilt more readily and will not sell well. Harvesting should furthermore not be done after an irrigation. Then the leaves are crisp and brittle and breaks easily in handling. If just slightly withered they are injured less in handling and packing and consequently will carry better transit. Cabbage should be cut above ground. Then the stumps give a crop of sprouts which if tendered carefully supply another gathering.

The yield was recorded by the number of heads harvested and sold. The production of cabbage averaged about 8,000 good heads per acre. The prices received averaged 18 cents per head. The cost of cultivation was estimated to be Rs. 400·00 per acre including cost of seed, manures, labour and irrigation. This leaves a nett profit of over Rs. 1,000·00 per acre. But these figures cannot be regarded as stable. The novelty of the crop made the local consumers pay a price which cannot be demanded by an established industry. But even at a price of 10 cts. per head a substantial margin of profit will remain.

WASTE BY WIND AND WATER*

[In view of the general interest being taken in soil erosion in Ceylon at the present time, the following article by a leading authority on soil conservation in the United States may be of interest to readers.—Ed. T. A.]

It was not so long ago that enormous dust clouds were rolling out of the Middle West to drop a stifling shroud over the country from the Mississipi Valley to the Atlantic Coast. In June, raging flood waters were bringing havoc to portions of three western states. The first week of July witnessed a tornado in Montana and a cloudburst and flood in New York. Since then Ohio and Wisconsin have experienced record-breaking rains followed by flood waters, and just a short time ago a disastrous hurricane in Florida was accompanied by torrential rains as far north as Maryland. Damage was estimated at millions of dollars.

But the estimates failed to include the most permanent damage of all—the destruction of the soil. Houses and other properties destroyed by the raging waters can be replaced; crops swept out by prairie winds can be replanted. But the fertile soil blown high into the sky or washed by the ton into streams and rivers is lost forever. Spectacular and destructive as these storms are, and as violent and harmful as the floods have been, they do not constitute the really great menace to our soil resources.

The truly tremendous waste is constant. Ruination of the soil is not confined to brief periods when nature exerts the full force of her elements. It proceeds steadily wherever man's cultivation of the land has bared the soil to the wash of descending rain and the sweep of the wind. There is no way of preventing cloudbursts. We have to accept them as they come and hope they will be few and far between. All we can do is attempt to control the floods that often follow.

Dust storms are different. Where cloudbursts are the product of some strange array of nature's elements, dust storms are brought on by man's own misguided failure to protect the soil as he tills it. By simple reasoning, therefore, if he can be guided into the use of practical measures of soil conservation, the cause of the dust storms will be removed. The very nature of these storms has given rise to the popular belief that they are the beginning and the end, the fact and symbol of all soil erosion. This is not true. The gradual washing away of rich topsoil by the runoff of rain-water is far more serious because it is not only constant but wide-spread.

In the work of erosion control, we have come to divide soil erosion into three classes; namely, wind erosion, sheet erosion and gullying. I need only to recall the dust storms to define wind erosion. Sheet erosion is the washing

*By H. H. Bennett, Chief of the Soil Conservation Service, U. S. Department of Agriculture in *The February Scientific Monthly*.

away of a thin layer of topsoil from sloping fields. Gully erosion follows in its wake to cut deep chasms and ravines which ultimately ruin our fertile fields for cultivation. So we find our country's soil damaged by both wind and water.

Few people realize how tremendously important this land wastage problem really is and how certain it is to effect the permanent welfare of the nation. It is not generally known, for example, that approximately 50 million acres of our erstwhile fertile farm land has been essentially ruined for further practical cultivation; and that another 50 million acres is bordering on this tragic condition.

A nation-wide erosion survey, conducted last year by the Soil Conservation Service, revealed that the extent of damage and ruin to basic farm land far exceeds all prior estimates, and that the 100 million acres so severely impoverished or ruined do not tell the whole sad story. Something like 125 million additional acres, still largely in cultivation, have lost all, or the greater part of their most productive topsoil, with a direct decrease in crop yields that is appalling.

And here, for a moment, I should like to discuss the philosophy which underlies our objective of soil conservation. Right now, as every one knows, agriculture in this country is facing an economic crisis brought on by an accumulation of circumstances in which over-production had a leading rôle. Few people realize, however, that agriculture also faces a physical crisis of tremendous importance to the continuing welfare of this nation.

The remedy for the economic problems which confront the farmer must necessarily be of an economic character. It is, of course, necessary to adjust the total production to the total effective demand. Certainly there is no virtue in producing so much that the price drops to a point which is less than the cost of production. It is never advisable, it can never be wise, to sacrifice productivity. There is nothing incompatible or inconsistent between adjustment of production and conservation of natural resources. For the entire agricultural structure, after all, depends fundamentally upon the physical integrity of the soil. If that physical integrity is depleted at a rate which will see our entire cultivated acreage virtually non-productive in half a century, there is no alternative for conservation. In other words, while we find it essential to control production, we must at the same time exert every effort to lower production costs, widen markets, improve quality of products and—this is what I wish to stress—maintain our basic resource, the soil. There is a danger, when the country is confronted simultaneously with agricultural crises of an economic and a physical nature, that this distinction may be obscured.

We likewise should remember that thousands of farmers have suffered continuous losses in revenue and are now fighting a losing battle against the poverty which is at least partially the result of extravagant, careless land use, as well as of price declines and maladjustments of the economic balance. If the farm land already ravished and ruined by soil erosion should be divided into 80-acre farms, and restored to its former productiveness, it would be physically capable of supporting no less than 1,250,000 families!

Soil erosion is a serious problem in every one of the 48 states. Naturally, in some states it is more acute than in others. Nebraska, for example, has been affected considerably more than Delaware. Erosion is more prevalent in Texas than it is in Vermont.

Yet we have learned from sad experience that a state comparatively free from erosion this year may be seriously menaced within a decade unless proper care is taken to conserve the soil. Who would have predicted, back in 1925, that the entire Midwest would be so severely hit by dust storms in 1935? Who would care to predict what will happen in 1945 unless measures to protect the soil are taken at once? As can readily be understood, this is a national problem, which must be met on a national scale. The problem has gone beyond the local stage. It is no longer the concern of the individual farmer whether his land is washed or blown away. The very basis of America's future farming prosperity is at stake and that stake is too high for any but the most profound of considerations. Active leadership by state and federal governments is essential.

So the Soil Conservation Service, one of the youngest of established Federal Service agencies, has been assigned the job of saving our remaining area of good farm land from destructive erosion. It is a sizable commission, but we are moving ahead. The Service proposes to promote farm practices that will protect and conserve the farming lands of the country for permanent agricultural use. Certainly there can be no broad advance or strengthening in the individual farm position; or in upbuilding farm communities, until the land involved is stabilized in relation to soil erosion. In different words, the betterment of economic and social aspects of farm life is closely linked to the solution of the erosion problem.

If the Soil Conservation Service can initiate erosion-control measures on all seriously eroding lands within the next 10 years; if it can secure reasonable control of erosion within the next 20 years; and if it can establish preventive measures on practically all the better lands of the country within the next generation, it will have gone a long way toward solution of the problem. Although the Service has been in existence less than two years, it has already brought an area of approximately 40 million acres under its influence. Plans for expansion will more than double this area at an early date.

We appreciate the gigantic proportions of the task in front of us and are approaching it in all humility. We realize that the job can never be completed successfully without the concerted action, the consistent support and the creative co-operation of the whole people. For, after all, it is primarily and fundamentally a problem of the whole people. The task of conserving the soil is so vast and erosion has already made such headway that the Service could not possibly hope to treat all the land of the country, acre by acre, with necessary measures of erosion control. The job must be done through co-operation between federal and state agencies on the one hand and the farmers and landowners on the other.

The procedure adopted at the outset is one of demonstration. In this way the Service is able to carry its program to the greatest number of

farmers with the least expenditure of time and money. As any thinking man will realize, the work of soil conservation must be carried on as economically and quickly as possible.

So, by demonstration, the Service is attempting to show that the impoverishment and destruction of our remaining areas of good agricultural land can be curbed to a very large degree. At the same time it is laying the foundation for a permanent national erosion control program of scope sufficiently broad to meet the acute land crisis created by wasteful methods of land utilization.

As a step towards its goal, the Service has established, or is in the process of establishing, 141 demonstration projects in 41 states, with the average working area for each project limited to approximately 25,000 acres.

Usually a demonstration project comprises all the land within a watershed ; that is, all the land lying within the drainage basin of a given stream. Each project area is selected with the most careful consideration of its adaptability to an effective demonstration and its availability for inspection by a large number of farmers. In other words, a project area must be readily accessible to a great number of farmers and it must present erosion problems that are representative of the entire surrounding countryside. If water erosion is prevalent in the region, the project area must present opportunities to demonstrate how water erosion can be halted. If gullies are numerous around the countryside, work on the project must show how gullies can be controlled.

The farmers of a project area enter into contracts with the government, whereby they agree to operate their farms under guidance of the Soil Conservation Service, to furnish as much labor and material as possible to put the program under way, and to maintain for a five-year period the cropping plans and erosion control structures installed by the Service. In return, the Service agrees to lay out a complete erosion control program for each farm, supervise the work and furnish whatever supplementary labor and material is needed to do a complete job.

Once the Service has placed its control measures in operation, the farmers in the surrounding territory are invited to visit the project and inspect the methods being used. It is hoped in this way to show them just how they themselves can control erosion on their own farms. A demonstration project is in fact a show window.

Today more than 10,000 farmers have signed formal co-operative contracts, agreeing to carry out for a period of five years the control measures recommended by the erosion specialists as most adaptable to the needs of their lands. Yet the problem of soil erosion extends even further. In addition to the enormous loss incurred by abandoned acres, reduced crops yields and decreased fertility, the country is paying a heavy price for damage to its power and water supply reservoirs, its irrigation systems and its harbors and waterways.

Soil that is valuable on a farm is a menace when it begins to fill up our reservoirs and waterways. The soil washed from farms eventually empties into streams and rivers. Channels that have been deep have become shallow.

Unable to hold the volume of water within its banks the river grows wider and wider, over-running its former boundaries. The possibilities of floods are greatly increased.

Frequently the silt washed from farm lands comes to rest in the bottom of a reservoir. Little by little the reservoir fills up. The capacity is decreased. Millions of invested dollars in the reservoirs are endangered. Social and economic values dependent upon the reservoirs are jeopardized.

The control of erosion is essentially a matter of better land use. It means that we must be more careful—much more careful—of the type of crops we plant, where we plant them and how often we plant them. It means that the day of unintelligent farming is past, just as surely as the day of farming by superstition is past. We have progressed beyond the stage where farmers plant their crops only during certain phases of the moon and harvest accordingly. Farming today must be as efficient as a city industry.

The program of the Soil Conservation Service aims primarily at the establishment of agriculture on precisely such a basis of efficiency. Adoption of the program does not mean that production will be impaired. On the contrary, we have already proven that protection of the soil is compatible with production. Our objective is merely to readjust agricultural practice to the needs of the soil.

The realization of that objective is far off. Years of tradition have dictated the farm practices now employed in many of our major agricultural regions. We should be tilting at windmills were we to attempt an overnight rearrangement of these practices, though, to be sure, we have accomplished almost that in several localities. We must proceed carefully, slowly and thoroughly to convince the farmer that our way is better than the way his father taught him. We must strive to inculcate in his mind a faith in our methods as strong as the faith that links him to the soil. We must instill into the farmers of America that almost reverent attachment for the land which has preserved the agriculture of certain smaller agricultural countries through the centuries.

Ours, certainly, is a goal fully worth the striving. For its attainment will mean that our children, and their children, and their children after them, in truth, "will inherit the earth."

VERNALIZATION PLANTS*

THE idea of vernalization originated as a result of a new outlook on plant growth and development formulated by the Odessa school of plant physiologists headed by T. D. Lysenko. Until 1930 it was unknown to wider circles of agriculturists, though since that time it has assumed a very prominent place in agricultural literature and thought. The general principles of the theory are now widely familiar. These are roughly that the growth and development, far from being identical as has been popularly supposed, are in reality two distinct and separate phenomena. Growth is regarded merely as increase in size and weight and such changes as flowering and reproduction are included under development. According to the new theory either of these two processes may proceed independently of the other, so that we may be faced with the extraordinary case of a plant which comes into flower without having grown or a plant which grows for ever without ever coming into flower. All that it is necessary to do, it would seem, to produce such remarkable behaviour, is to treat the plant in such a way that one of the two processes is favoured to the exclusion of the other. If seeds of winter wheat are germinated in an ice box and subjected to suitable conditions of light, aeration, humidity and other factors, they can be sown in spring and will come into ear at the same time as if they had been sown in the ordinary way in autumn. Hence the term "vernalization," which is a latinized equivalent of the Russian word "Jarovizacija," coined by Lysenko to describe the phenomenon and which strictly means "transformation of winter forms into spring."

The matter was first brought to the attention of English-speaking readers by a bulletin issued in 1933 by the Imperial Bureaux Plant of Genetics. This early bulletin gave a complete outline of the method as it was described in Lysenko's first publications, and consisted mainly in the description of a practical method for the pre-sowing treatment of seed to obtain this accelerated development in a variety of crops. This method was rapidly seen to be of practical importance not merely in Russia but in all parts of the world. In view of the wide interest taken in the subject the Imperial Bureaux have continued to collect the literature relating to it. This has assumed such magnitude and the subject has become so much extended in its range that the whole matter has been reviewed afresh in a new and much enlarged bulletin covering some 150 pages, obtainable from the Imperial Bureaux, School of Agriculture, Cambridge, price 10s.

* From *The Rhodesia Agricultural Journal*, Vol. XXXIII, No. 3, March, 1936.

This new bulletin describes in detail the results of the many experiments that have been carried out on all sorts of crops under every possible condition, both in the Soviet Union and in other countries all over the world. The results of vernalization of over 6,000 varieties of wheat and of 500,000 hectares of vernalized sowings, based on replies to a questionnaire received from 1,056 different Soviet farms, are reported. The results have on the whole been satisfactory when the necessary conditions of technique have been observed and it would seem that the method may now be definitely regarded as a useful agricultural measure in countries where early ripening is a decisive factor in successful cultivation. For instance, spinach, sugar beet and even potatoes have by suitable treatment been grown at Hibiny in the Arctic circle. Cereals have been induced to ripen a week or more earlier, and by this means it has become possible to extend their cultivation to large tracts of country where this has been impossible hitherto because of drought or other unfavourable conditions. The main results of the Russian workers have now been confirmed in most countries where vernalization has been tried. In countries of more normal climatic conditions the method will probably not be of such wide application to the main crops, but in the case of salad, vegetable and market garden crops a difference of a few days may prove of tremendous economic importance and a considerable future is foreseen in the application of vernalization to plants of this type. The Russian workers have even claimed to get increased yields from vernalized sowings, but there seems to be some difference of opinion on this point, and others have observed a depression in yield after vernalization.

At least half the bulletin is devoted to the physiological aspect of the phenomenon of vernalization. Lysenko's original conception has been extended to cover the whole range of plant development, in the form of the theory of Phasic Development. Development, says Lysenko, consists of a series of stages, each of which requires for its completion a definite combination of external conditions. The conditions for one phase may be different from those required for others, temperature being the decisive factor for the first stage and light for the second. Each stage must be completed before the succeeding one can be initiated, but once any stage has been completed there is nothing to prevent the progress of the following one, provided the necessary external conditions are forthcoming. The method of vernalization therefore consists in the provisions at as early a point in the life of the plant as possible of the requisite conditions for all the developmental stages leading up to reproduction, thus curtailing the long periods of time that normally occur between these successive stages. A freshly germinated seed has been found to be the most suitable material to work on, as this can be conveniently treated before sowing and then sown in the ordinary way.

Other Soviet botanists, though agreeing with Lysenko's general findings, disagree with many of his conclusions and have put forward theories of their

own. The views of these other workers are presented in the bulletin side by side with those of Lysenko in a spirit of pure impartiality. In fact, a careful study of this bulletin shows that it has dealt with the available information from all possible points of view, equally generous treatment being given to the practical application of the method in agriculture and horticulture and to its theoretical explanation. It will be of interest to plant physiologists, biochemists, plant breeders, teaching botanists, and indeed, to anyone concerned with modern trends of botanical and agricultural research. "The rapid development in scientific research is one of the outstanding features of the Twentieth Century," as Sir David Chadwick aptly remarks in his foreword. "Research workers need the earliest possible information of developments affecting their line of study, but frequently find themselves baffled by its volume and by linguistic difficulties." To overcome these difficulties the Imperial Agricultural Bureaux were organised in 1929 and the bulletin under review affords an admirable example of how these Bureaux fulfil their function. The large majority of the articles with which the bulletin deals are written in Russian and would have remained entirely unknown to the rest of the world if they had not been made available in the present form. A total of over 200 separate articles are considered and reviewed in detail and large sections of the tabulated results of the authors are reproduced in a review of the work of the whole world on this controversial but entrancing new subject.

RECENT WORK IN PLANT BREEDING*

FOR some eight thousand years man has been engaged in the breeding of plants for his own use, and during these long centuries of time there has been a steady improvement of all the plants which provide him with material for food, clothing and ornament. Up to thirty-five years ago this improvement was for the most part haphazard and accidental; though in fact intelligent selection of the best and most useful varieties was constantly practised, and any new improvements unexpectedly arising were carefully preserved. Actually the progress achieved by these non-scientific but commonsense methods was extraordinarily good, but owing to a lack of knowledge of the laws of heredity it was of necessity extremely slow and often wasteful in effort and outlay.

In 1900 the finding of Mendel's long-lost paper disclosing his discovery of the fundamental laws of heredity caused a complete revolution in breeding. To their credit plant-breeders were quick to grasp the importance of the new facts in helping them to a more speedy and a surer solution of their problems. In all cultivated plants new work was enthusiastically carried through, old varieties were tested and purified and new varieties were raised which contained a preponderance of desirable qualities. The further discovery that all heritable characters, whether structural or functional, were due to the actions and reactions of the minute living molecules known as genes, situated in the chromosome threads of the nucleus of each cell in every plant and animal (including man), was a still greater cause of progress. It was immediately realised that the best results in breeding could only be obtained by an intensive study of the chromosomes and genes of any plant which was being used. This study revealed many startling facts, and provided a complete explanation of some hitherto quite inexplicable difficulties. It is safe to say that the union of the two new sciences of Cytology and Genetics into one was one of the greatest revolutions ever brought about in biological science and is bound to have the greatest possible influence on the future of man.

After thirty years of concentrated experiments by a great number of research workers with millions of plants and animals in the numerous laboratories and research stations which had sprung up all over the world, it was realised that in many cases the limit of improvement had been reached. The existing varieties had been bred to such an extent that their possibilities were more or less exhausted, their desirable genes had all been utilized and all the most desirable combinations had already been attained, though in many cases the ideal had not been fulfilled. Only one thing could give further progress—the introduction of new genes and new methods of combining them with the old genes.

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*By C. C. Hurst, Ph.D., Sc.D., Trinity College, Cambridge, in *The Empire Cotton Growing Review*, Vol. XIII, No. 2, April, 1936.

The discovery that new mutations could be produced by X-raying gave a new stimulus to the work. Unfortunately, as in all natural mutations, the great majority of X-ray mutations are pathological or lethal, so that although their incidence is enormously increased the production of new forms of real value by this means involves considerable labour in testing large progenies. Fortunately a new and extremely profitable method arose in the hybridization of widely distinct species and even genera which, by their combination, brought together entirely new gene-complexes of a highly desirable kind. Hitherto the union of different species had brought about little success owing to the sterility of the hybrids. The discovery that a duplication of the entire chromosome set of the hybrid either in the germ cells or in the body cells (Hurst, 1933, 1935) produced fertile germ cells and progeny and created new species and genera, gave new hope to this branch of breeding which has proved to be amply justified. In this connection the use of X-rays is of great value, for one of the most useful results of this treatment is the duplication of chromosome sets. In an ordinary species this is important, although not of vital importance, since it only increases the size of the individual without producing any other desirable genic changes, but in these specific or generic hybrids it is of the utmost value, for it converts a sterile hybrid into a fertile and pure-breeding new species or genus combining the qualities of the two parent species, and containing a new complex of genes which often in their reactions together give rise to new qualities. Above all the new forms possess greater potentialities for mutation in the greater number of genes, and hence afford more hope for the production of new varieties.

Here we come to the real essence of modern plant-breeding. Once the possibilities of interspecific and intergeneric breeding were realized, the introduction of new genes became an all-absorbing problem. The great work of the modern breeder is the search for new genes, especially those which give resistance to the numerous and devastating diseases which attack crops in every country. Fortunately, it has been discovered that in most genera there are many wild growing species which are immune to the diseases which attack cultivated plants, and by using these species it is hoped to be able to produce disease-resistant plants which will still contain all the desirable points of our best cultivated varieties together with the addition of other good characters which are not yet present.

Under their able leader Dr. N. I. Vavilov, the Russian plant-breeders have been in the forefront of this new phase of breeding. Expeditions have been sent out to every country in the world to collect all the possible species allied to the plants which constitute our present crops, and also to discover new sources of the various commercial commodities, such as fibres, oils, rubber, etc. In addition to the wild growing species there are many ancient species and varieties still in cultivation in remote and outlying districts which contain valuable qualities, especially in their adaptation to peculiar and exacting environments. One of the great problems of modern plant-breeding, besides that of disease resistance, is the production of varieties which will give a full yield under adverse conditions. In a country such as Russia, and within our own Empire (under such diverse conditions as exist in Australia

or Canada), there is a great need for new varieties and new types of crops fitted to each particular type of locality. It is useless to expect a high-yielding, disease-resistant plant fitted to normal conditions to function adequately in districts subject to drought or to extreme cold ; such districts must have their own varieties specially bred for them. For this purpose the old-type crops of the isolated communities are ideal, for they have, through countless generations of natural selection, become adapted to their environment, which in many cases is of a highly specialized character, since they are usually found in out-of-the-way mountain districts or under steppe or desert conditions. In these districts there is a wealth of new genes to be found in every kind of cultivated plant fitted to all possible conditions.

The experimental stations throughout the world are making exhaustive collections of the likely wild-growing species and of the locally cultivated crops, and from the new gene combinations arising from their hybridization with our existing crops great hopes are entertained.

Cotton.—In cottons work has been proceeding steadily all over the world. In attempts to produce cottons suitable for their diverse environmental conditions the Russians have put in an immense amount of work in studying the genes and chromosomes of varieties and species, and have carried through numbers of hybridizations. At Tashkent, a study was made of ginning percentages by investigating the number and weight of the fibres and weight of seed, and it was found that there was a wide deviation in this respect between different cottons. The number of fibres per seed in seven varieties of American cotton varied from 7·8 to 14·7 thousand, while the weight of a thousand fibres varied from 4·4 mg. to 7·6. mg., and the seed weight from 97·0 to 167·2 mg. In *G. herbaceum* the number of fibres per seed varied from 3·6 to 9·2 thousand, the weight of a thousand fibres from 3·4 mg. to 5·8 mg., and the seed weight from 69·7 to 111·8 mg. Crosses have been made in which it is hoped to combine the higher number of fibres with the heavier weight, and in the second generation of a cross between two lines of *G. herbaceum* some plants arose with the desired combination and showed a ginning percentage of from 7 to 13 per cent. higher than the better parent. In the fourth generation a true breeding line was obtained in which the percentage was 8 per cent. higher than the better parent.

The type of boll in *G. herbaceum* is very variable, but the closed boll proved to be a simple mendelian recessive to the open or semi-open boll, both of which are undesirable in mechanical harvesting. Size of boll was found to be dependent on a number of genes in American cottons, and it was necessary to grow some thousands of F_2 seedlings to obtain the desired types. By crossing with early maturing forms it was also found possible to unite high yield with early maturity. Many other points were studied, and it is pointed out that since a large number of genes are involved in these cottons it is wiser to limit the parental combinations as much as possible in producing new varieties by hybridization, and to grow the largest possible number of progeny. Back-crossing is also useful for reducing the number of segregating types in later generations.

The Transcaucasian Cotton Research Institute have issued a bulletin describing the progress made in the acclimatization of Egyptian Cottons; descriptions, illustrations and lint qualities of selected new lines are given. The varieties have been divided into six groups based on their maturity periods. Another publication from Moscow gives the spinning qualities of a number of the best improved varieties grown in the U.S.S.R. Varieties of the Pima type of Lower Egyptian Cottons have been grown under varying conditions for comparison. Upper Egyptian types, including Ashmouni and allied varieties, Uplands and strains with medium staple, have also been tested. It has been found that by means of transplantation it is possible to grow high-quality Egyptian varieties in the region of Tashkent, and some selections of Pima can be spun to 120 counts. Longstapled Uplands, however, are superior in yield, and are as good as the Egyptians for spinning 50's and 60's.

The experiments in vernalization of cotton were attended with much success, not only in producing a higher yield under normal conditions, but also in several cases, in increasing in lint length. The seed is moistened and then kept at a temperature of 25° to 30° C. for varying periods. It was found that the best results were obtained after ten to fifteen days' treatment for Navrotskii, fifteen to twenty days for Acala 8517, and fifteen days for the Egyptians; longer periods caused depression of germination and shorter periods had no effect. The chief effect of optimum treatment seems to be a more rapid completion of the various phases of development rather than any particular acceleration of their inception. All the varieties vernalized germinated from two to three days earlier than the controls, but later stages showed considerable variation. In the American cottons treatment produced a tendency to higher ginning percentage and length of lint, but in the Egyptians the ginning percentage was increased while the lint length was slightly decreased. The flowering period was usually from three to four days earlier, but in Navrotskii it was as much as thirteen days, and in Ashmouni nine. The differences in maturity were often greater, varying from four to fifteen days earlier. In all cases the plants treated in the Russian experiments showed an improvement over the controls and it is probable that this method may be of much value in growing crops in those regions not naturally fitted for them. Certain cases of failure are attributed to imperfection of technique rather than to any deficiency in the treatment, and different varieties gave widely different reactions; in some cases there were even differences within the varieties themselves. It is pointed out that greater knowledge is needed before the best results can be expected. The effect was that treatment was considerably greater in 1933 (which was a very bad season for cotton-growing in the new regions) than in 1934, when the natural conditions were more favourable to normal growth. Vernalized sowings were made on a large scale on collective farms in 1932, 1933 and 1934, with an increase from 600 ha. to 3,000 ha. under cultivation in the three years. The average yield increase was from 0·3 to 2·5 centner per ha. but on one farm the yield increased in the treated crops was four times that of the untreated.

At Tashkent experiments were also made on the photoperiodism (adaptation to length of light-day) of the cotton plant, subjecting different

varieties to daily illumination amounting to 6, 9 and 12 hours against the average of 14 hours of the controls growing under normal conditions. Observations showed that cotton is essentially a short-day plant, which complicates its successful growth in long-day regions, since a reduction of illumination causes early maturity. Different varieties, however, show different heredity reactions corresponding to the position of their original environment with regard to the equator, those from equatorial regions needing the least light and this effect becoming less and less as their place of origin is further removed from the equator. The general effect of the shortened illumination is the production of sympodial branches at a lower level and consequently an earlier production of flowers and bolls. By making the necessary comparative alterations in the daily amount of light it is possible to synchronize the flowering periods of widely divergent varieties and species, and to make crosses hitherto difficult owing to the difference of their flowering seasons in these new regions. Crosses have thus been made between Egyptian cottons with low boll weight and several South American cottons with very large bolls but of short day and perennial habit.

Within our own Empire work on the improvement of cottons is also steadily proceeding, but this is too well known here to need repetition.

Beans.—New varieties of Soya beans have been produced, suitable for conditions on the Ukraine Steppes. Those previously grown proved unsuitable for mechanical harvesting owing to the pods occurring too low down on the plants. Of the new strains produced one is equal in yield to the best imported types and is early maturing, while another provides superior fodder. In Uruguay, where the varieties are successful elsewhere have proved failures, a collection of 233 varieties from widely different sources and conditions has provided ten promising types. Selected lines of these have given very high yields, and others have been bred which are resistant to drought, which normally has a very adverse effect on germinating qualities, both at harvest and sowing. The best of these new lines have a protein content of 34 to 39 per cent. and oil content of 14 to 20·5 per cent. with a yield up to 1,000 kg. per ha.

This wonder plant, the "staff of life" in the Orient, which provides meal, oil, food for cattle and a fertilizer, has also been successfully introduced into England by careful selection of early maturing varieties and their acclimatization for several years by Mr. J. L. North. The remarkable properties of the Soya bean are not yet appreciated by the British farmer, and a book on the subject has recently been written by Miss E. Bowdidge to make its cultivation more popular. It is to be hoped that its value may soon be realized and taken advantage of by its widespread cultivation.

Cereals.—Work steadily proceeds all over the world to produce new improved forms capable of cultivation under diverse conditions, and to provide each district with an ideal variety by hybridizing the highly specialized local cultivated forms and species with the high yielding normal types. The new genera formed by generic crosses between wheat and rye, and wheat and *Aegilops* in Russia and Germany have already been described in this Review (Hurst, 1932), but recently an even more interesting line of investi-

gation has been opened up in the hybridization of wheats with the couch-grass *Agropyrum*. This grass is perennial, and it is hoped thus to produce perennial wheats of extreme hardiness for cultivation under adverse conditions. Three species of *Agropyrum* have been successfully used in crosses at Saratov. The first-generation plants are very luxuriant, forming up to 150 heads on one plant. They show a preponderance of *Agropyrum* characters, which is to be expected since *Agropyrum* is a decaploid with 70 chromosomes (10 sets) while *Triticum vulgare* is a hexaploid with 42 chromosomes (6 sets). The hybrids were all perennial and fully resistant to frost, and the first generation of *T. vulgare* crossed with *A. elongatum* is distinguished by excellent fertility, one plant giving as many as 665 grains. Other crosses showed diminishing fertility according to the parentage. In the second generation wide segregation occurred, but the fertility was higher, the grains being large and vitreous. In the third generation many plants showed quite normal fertility, the grain being mainly of the wheat type. Several of the hybrids showed resistance to rust and smut, and freedom from shattering, with the addition of various other valuable characters, and this new breeding work is obviously of great practical importance. It is evident from the results obtained that certain species of couch-grass have a very close affinity with certain wheat species, their distinction apparently lying only in their two extra chromosome sets. Thus *T. vulgare* may be designated A + B + C and *Agropyrum* A + B + C + X + Y, other species of both having variations. Hence it should not be difficult to fix desirable types in future generations, and it is also probable that some fortunate duplications may occur to hasten the process.

The new genus *Secalotriticum* (Rye × Wheat) (or *Triticale*) is already grown on a large scale. The most notable achievement of the Russian grain-breeders however is probably the distribution of a very large number of improved varieties of the chief grain crops (wheat, barley, oats and rye) especially suited for cultivation in all the main regions of the Soviet Union, including the arid zones. This has been achieved in the north by the production of ultra-early spring wheats and new hardy winter varieties. One of the new early oats is also highly resistant to drought and rust. The hybrid *Avena sativa* × *A. Byzantina* exceed the standard yield by four times, and showed considerable resistance to leaf-rust, and a new rye produced by crossing a local form of Detskoje Selo with Rýmker also showed a great increase. Further improvements are still required, however, especially in disease resistance. From a close study of the methods used it may be seen that all the desirable new qualities have been introduced by using local varieties in crossing, since they possess the essential genes for resistance which are needed by the existent varieties.

The Russian world collection of wheats shows that there are four groups of early maturing wheats: (1) Arctic, (2) from continental regions of the subtropics, (3) from mountain regions, (4) from countries of periodic rain such as China and Japan. In other respects however, these wheats are very different: those from the north need little warmth but much light, and those from the south are resistant to heat but need little light. By the requisite crossings early maturing forms can be raised with varying reactions according to the latitude for which they are required.

Great improvements have been carried out in India on wheats and barleys so that they can now compete in quality with any in the world. At Pusa, types resistant to all the three rusts prevalent in India have been produced. In Egypt since 1921, work has been carried out with great success in the improvement of cereal crops by hybridizations between the native forms and imported varieties. In Australia, collections of cereals from all parts of Australia and other countries have been made in order to breed types fitted to all the very varied conditions of the continent. Three or four hundred valuable new lines have already been isolated and are undergoing exhaustive trials. All European countries as well as America are working on the same genetical lines, and the work done in cereals throughout the world is one of the greatest tributes to the success of modern genetics.

X-ray experiments with wheats show that each variety has its own particular reaction. The soft spring wheats give a great variety of mutants, while the *durum* varieties give a larger number of mutants but a limited number of types.

In China, work is being done in the hybridization of cultivated rice with the wild forms. A valuable new variety with vigorous growth, resistant to cold and to a high percentage of acidity in the soil, has already been produced. In Japan, experiments with X-rays, ultra-violet rays and temperature changes has induced all the known mutants of rice and other new ones, and in some cases mutants ripened 11 days earlier than the parents.

Lupins.—The Kaiser Wilhelm Institute have put on the market new alkaloid-free lupins which will grow on the most unfavourable light soils and produce extraordinary quantities of green fodder. Crosses between bitter and sweet lupins showed that absence of alkaloid is a simple recessive. The Russians have also done very much in the production of alkaloid-free lupins, having made two and a half million analyses in two years. The great advantage of these new lupins is their high yield and protein content and their capacity for growing on sandy soils where other crops cannot be produced. A common bitter lupin has been discovered with 21 per cent. oil content against the usual 4 to 6 per cent., and it is hoped to combine this new feature with the alkaloid freedom. Disease resistance is also being investigated.

Rubber.—The Russians have made expeditions also to discover new rubber plants suitable for cultivation in their temperate regions. Analyses of 1,048 species of 316 genera belonging to 95 families have been made, and rubber was found in 609 species. The best results were obtained within the *Compositae* family. A plant found in the Caucasus, *Scorzonera tau-saghyz* showed a higher rubber content than any plant known, the rubber being of high quality and easy to extract. Its unusual capacity for regeneration was also a marked peculiarity of this new species.

Tobacco.—In Russia, work is constantly proceeding to combine the hardiness and adaptations of local varieties with the finer flavour of more desirable varieties. Many extremely interesting compound types have been built up containing the chromosome complexes of three species of

tobacco. Much segregation occurs, and desirable new types can be fixed in later generations. These synthesized varieties form a valuable reservoir of new and valuable forms, and correspond to the similar experiments in cereals. In America several pure breeding new species and varieties have been built up in this way, by hybridization followed by chromosome duplication or segregation. The use of ultra-violet rays was found to give rise to conditions of greater fertility in the hybrids. Goodspeed and others find that the tobacco plant is a specially good subject for X-ray treatment, and several useful mutants have arisen by this means. In one case fourteen different types were obtained from a single X-rayed sex cell ; seven were pure breeding derivative types, the others are not yet constant.

Much work has also been carried out with such crops as bananas, sugar-beet, cacao, coconuts, coffee, hemp, potatoes and sugar.

In so short a space it is not possible to deal adequately with any one of the many lines of research being pursued, but enough has been mentioned to show how very much alive scientific plant-breeding is all over the world. Just as new genes are being introduced into existent crops, by the utilization of new species and local forms, so other wild species are being tested and tried out to produce new types of crops. Although the Russians have led the world in the exploitation of world resources, yet there are still untapped reservoirs of wild plants in the Soviet Union itself, many of which are promising new sources of rubber, fibres, etc. The great forests of South America are still largely unpenetrated by man, and one may expect vast stores of vegetable wealth to be had there for the seeking. Above all in China there is an unparalleled wealth of species and forms, often extremely localized. The intermingling here of tropical and temperate floras has resulted in the evolution of a vegetation of unequalled richness and variety. Our own plant collectors have shown us to some extent the horticultural treasures which are to be found there, but the great store of economic forms is still scarcely touched. Chinese forms are also generally characterized by a happy immunity from disease, and many cold-resistant forms of fruits, etc., which are at best only half hardy in the case of those now in cultivation, exist in the northern mountains and at higher altitudes in the south. Excessively late or early forms, wide variations of colour, form, size, flavour, yield, etc., promise an almost inexhaustible store of genes for the future. Thus we may look forward to a very considerable improvement in all our economic crops, fruits, vegetables, and flowers within the next few years with special adaptations to all the diverse environments of the various continents. The future of plant breeding is indeed bright, and although much labour will be involved it will be more than worthwhile in the usefulness of the results.

BROADCASTING VERSUS TRANSPLANTING OF RICE*

Introduction.—Of the two practices, direct sowing and transplanting, the latter is by far the more important and it may be said that wherever facilities for transplanting obtain people will prefer it to broadcasting. It would be safer to say that four-fifths of the rice grown in the world is transplanted, and almost all countries like Spain, Italy, Japan, etc., where the highest acre yields are recorded adopt transplanting. Drilling is to a certain extent replacing the practice of transplanting owing to labour difficulties of transplanting as in California. In Italy where also labour is very expensive they have evolved a transplanting machine which can be worked in the puddle.

Broadcasting is usually confined to tracts where the water availability is uncertain and the season is not always dependable. The fact that the yield per acre is definitely higher for a transplanted crop is well recognised though the reason for this increase has not been explained satisfactorily by experimental evidence. It has been sometimes explained that transplanting acts in a way like root pruning : the injury to the root system stimulating the growth of the sub-aerial portion and resulting in increased tillering. It is also stated that transplanting gives a shock to the plant which stimulates better growth and better tillering and consequently better yield. This shock theory cannot, however, be accepted since seeds actually dibbled in lines evenly, yield as much as, if not better than a transplanted crop. In a small-scale experiment conducted some years ago at the Paddy Breeding Station, Coimbatore, comparing actual dibbling with transplanting in the case of two varieties, one a short duration variety, 3½ months, and another a medium duration one, 5 months, the dibbled plots gave decidedly higher yields than the transplanted. Similar results have been obtained in other parts of India and even outside India. If a satisfactory and practical method of actually dibbling the seed directly in the puddled field can be evolved there is no doubt that such a practice should prove an advantage over transplanting. The comparative merits of direct sowing and transplanting have formed the basis of experiments conducted at several of the Departmental Research Stations and the present note deals about such an experiment conducted at the Paddy Breeding Station, Coimbatore, for three seasons 1931-32 to 1933-34.

The Experiment.—The experiment was carried out with three strains as shown below :—

Season	*Strain No.*	*Duration of Strain*
1931-32	Co. 1	5 months.
1932-33	Co. 1	5 ,,
1932-33	Co. 8	6 ,,
1933-34	Co. 9	4 ,,

* By K. Ramiah, M.Sc., Dip. Agric., L. Ag., Paddy Specialist, and K. Hanumantha Row, B.Sc., Ag., Assistant to the Paddy Specialist in *The Madras Agricultural Journal*, Volume XXIV, No. 3, March 1936.

A row of fields was divided into a number of 2½-cents plots and they were all very uniformly prepared. At the usual time of sowing the nursery, every alternate plot was well levelled and the sprouted seed was sown in it directly as uniformly as possible, and on the same day the nursery for the transplant plots was sown separately. At the time the seedlings were ready they were planted in the alternate plots in the row. The broadcasted plots were not interfered with in the beginning and at the time of transplanting, the plots were given a weeding and the seedlings were thinned out sufficiently so that the number of plants in an unit area was the same in both broadcasted and transplanted plots. At the time of harvesting, the plots were divided each into two equal halves so that the arrangement of the plots was of the A B B A fashion. Each sub-plot was now harvested separately and the yield data analysed statistically.

Besides determining the final yield, the number of plants per unit area (half a square yard), the number of earheads in it, length of the panicles, height of plants, etc., were also recorded from random samples in the different plots so that an explanation could be offered to account for the final yield differences. The sampling was done by putting in an iron ring, half a square yard in area at different spots chosen at random in all the plots and taking notes of the plants inside such rings. All the data obtained are given below.

Year	1931–32		1932–33				1933–34	
Variety	Co. 1		Co. 1		Co. 8		Co. 9	
Treatment	Broad-casted	Trans-planted	Broad-casted	Trans-planted	Broad-casted	Trans-planted	Broad-casted	Trans-planted
Yield of grain in lb. of the experimental area—Total of 11 repetitions ..	372	392	278	352	221	313	210	288·5
Acre yield in lb.	2,706	2,851	2,022	2,560	1,607	2,276	1,527	2,098
Yield expressed as percentage of mean ..	98·6	102·7	88·2	111·7	82·4	119·6	84·0	115·8
Percentage standard error of the mean ..	2·6		3·8		3·2		3·0	
Number of ears per unit area (1/2 sq. yd.) ..	133 ± 6·6	101 ± 3·24	105 ± 3·60	96 ± 2·25	114 ± 3·22	103 ± 2·01	67 ± 2·61	84 ± 4·45
Mean length of panicle in cms.	—	—	19·0 ± 0·05	20·54 ± 0·06	17·88 ± 0·13	21·07 ± 0·14	20·2 ± 0·09	19·6 ± 0·08
Mean height of plants in inches	—	—	81·9 ± 0·80	88·4 ± 1·0	82·3 ± 0·84	97·8 ± 0·89	—	—

The season was a bit late in 1931-32 and the plants in the broadcasted plots which were infested by thrips (*Thrips oryzae*) could not make any headway in the early stages. This prevented proper thinning being carried out

with the result the number of plants per unit area in the two treatments broadcasted and transplanted, happened to be different. In the next two, years there was no such difficulty experienced, but still the number of plants in the broadcasted plots was slightly more than in the transplanted plots.

Discussion of Results.—In 1931-32, the yields of broadcasted and transplanted plots were almost the same. For the reason mentioned previously the broadcasted plot could not be thinned and it had nearly twice the number of plants per unit area as compared to the transplanted crop. The lower population density in the latter was made up by increased tillering. In the second year, the population density was only slightly more in the broadcasted plot in both the varieties, Co. 1 and Co. 8, and still the difference in yield in favour of the transplanted crop has been considerable. Though the number of ears per unit area has been slightly in favour of the broadcasted plots, the individual panicles of the transplanted crop have been definitely bigger in both the varieties, and the bigger ear has been the main cause for the difference in yield. In the trial with the *kar* variety, Co. 9, in 1933-34, the advantage of transplanting has again been brought about. Though it is usually considered that the two treatments cannot make a big difference with regard to short duration rices, under Coimbatore conditions in a normal season, transplanting appears to be better than broadcasting even in a short duration crop. Unlike in the two other varieties, Co. 1 and Co. 8, the increased yield of the transplanted crop in this case has been brought about mainly by the larger number of ears per unit area, the size of the ear in the two treatments not being different.

Other observations.—Root System.—Observations were made on the root system of some plants in the two treatments. It was found that in the broadcasted crop, the plants did not have such a well developed root system as in the transplanted crop. The transplanted plants had a more extensive and deeper root system and this is probably the reason for the broadcasted crop always having the tendency to lodge. In the transplanted crop the tillering and rooting zone is about an inch or two below ground level, and in the broadcasted crop, the seed having been dropped on the surface, the root system is more on the surface and it does not give sufficient anchorage to the plant.

Flowering, duration and height.—Though in the experiments the sowing of the seed in the broadcasted plot and the sowing of seed in the nursery for the transplanted crop were done on the same date, the flowering of the transplanted crop was sharp and uniform, while in the broadcasted crop, it was uneven and delayed. The harvest of the broadcasted crop could be made only a day or two later than the transplanted crop.

In 1932-33 where height measurements were recorded the transplanted crop in both the varieties, Co. 1 and Co. 8, was always taller in growth than the broadcasted crop, the differences between the two being significant. Although no actual weighments of straw yield were made, it was apparent that the quantity of straw was more in the transplanted crop.

Economics of the two treatments.—While in the case of the broadcasted crop there is some extra expense due to the higher seed rate used and to the extra weeding that has to be given, in the case of the transplanted crop, the extra expenditure due to the raising of the seedlings and transplanting the same is very much more considerable. As the figures given below show,

the value of the increased yield obtained from a transplanted crop not only covers the additional expenditure but leaves a clear extra profit. This net extra profit is about Rs. 14 in the case of Co. 1, Rs. 18-8-0 in the case of Co. 8, and Rs. 8-8-0 in the case of Co. 9, (*kar*).

	Co. 1 lb.	Co. 8 lb.	Co. 9 lb.	
Extra yield of grain per acre due to transplanting	538	669	571	
	Rs.	Rs.	Rs.	
Value of this extra produce ..	19–3–6	23–14–0	13–14–6	
				Rs.
Extra expenses incurred with transplanting:				
Cost of raising seedlings				5– 0–0
Transplanting charges				2– 4–0
Total ..				7– 4–0
Extra expenses in the broadcast crop:				
Cost of excess seed				0–12–0
Cost of one additional weeding and filling gaps				1– 2–0
Total ..				1–14–0
Net extra expenses in transplanting over broadcasting				5– 6–0
Net profit by transplanting ..	5– 6–0	5– 6–0	5– 6–0	
	13–13–6	18– 8–0	8– 8–6	

Summary.—The practice of raising a nursery and transplanting the crop in rice is always preferred to the direct sowing of the seed in the field. That the latter practice still obtains in some tracts is due to the uncertain seasonal conditions and inadequate irrigation facilities.

The comparative merits of the two practices were investigated into by regular experiments at the Paddy Breeding Station, Coimbatore. Three varieties of rice, a short duration *kar* crop, a medium duration *samba* crop, and a long duration *samba* crop were experimented with, and in every case transplanting was definitely found to be very much better than direct sowing. In the *samba* varieties the increased yield was brought about mainly by the bigger size of the earheads in the transplanted crop and in the *kar* crop by the bigger number of earheads per unit area. Even after allowing for the extra expenditure involved in the raising of seedlings and the transplanting of the same, the value of the extra produce obtained in the transplanted crop was enough to leave a clear net profit of Rs. 8 to Rs. 14 per acre.

RUBBER RESEARCH SCHEME (CEYLON)

Minutes of the thirty-first meeting of the Board of Management, held in the Committee Room of the Ceylon Chamber of Commerce, Colombo, at 2·30 p.m. on Thursday, 19th March, 1936.

Present.—Mr. C. H. Collins, C.C.S., (Deputy Financial Secretary), Mr. I. L. Cameron, Mr. C. E. A. Dias, J.P., Mr. L. B. De Mel, J.P. U.P.M., Col. T. G. Jayewardena, V.D., Mr. J. C. Kelly, Mr. F. A. Obeyesekere and Mr. C. A. Pereira.

Mr. R. K. S. Murray, Acting Director of Research, was also present by invitation.

In the absence of the Chairman, Mr. C. H. Collins was voted to the chair.

Apologies for absence were received from the Hon'ble Mr. J. L. Kotalawala, Mr. B. M. Selwyn, Mr. E. W. Whitelaw, and Col. T. Y. Wright.

MINUTES

Draft minutes of the thirtieth meeting which had been circulated to members were confirmed and signed by the Chairman.

BOARD

The Chairman reported the following changes in membership of the Board since the last meeting :—

(*a*) Resignation of Mr. L. P. Gapp and nomination of Mr. J. C. Kelly of Messrs. Mackwoods Ltd. in his place with effect from 27.2.36.

(*b*) Renomination of Col. T. Y. Wright to serve on the Board as one of the representatives of the Ceylon Estates Proprietary Association for a further period of 3 years from 21.4.36.

(*c*) Resumption of membership by Mr. B. M. Selwyn on his return to the island relieving Mr. R. Neville Rolfe who was acting for him.

A vote of appreciation of Mr. Gapp's services to the Board was passed. Mr. Kelly was welcomed to the Board, and Mr. Rolfe was thanked for his acting services.

DECISIONS BY CIRCULATION OF PAPERS

(*a*) Memorandum re soil erosion—Reported that the memorandum had been approved and sent in reply to the enquiry from the Central Board of Agriculture.

(*b*) Travelling expenses of the Director of Research in England—Reported that members had agreed to payment of travelling expenses to Mr. O'Brien for visits to factories, institutions, etc., as approved by the Chairman of the London Advisory Committee up to a total amount not exceeding £50.

(*c*) Mr. R. K. S. Murray acting on Budded Rubber Assessment Board Reported that members had agreed to Mr. Murray's serving on the Budded Rubber Assessment Board during the period of Mr. O'Brien's absence on leave.

RUBBER FLOORING COMPOSITIONS

A favourable report had been received from the Government Electrical Department regarding the power supply available at Dartonfield, and it was decided to apply to the Department of Industries for a grant of Rs. 30,000·00 to cover the cost of purchasing and installing machinery for manufacturing rubber flooring and other products on a semi commercial scale.

LONDON ADVISORY COMMITTEE

Consideration of the question of continuing to contribute towards the expenses of the London Advisory Committee was deferred pending the establishment of the proposed International Research Institute.

APPOINTMENT OF A SOIL CHEMIST

It was decided that a Soil Chemist should be appointed as soon as funds were available. In order to enable prospective candidates to qualify for the post it was decided to make it publicly known that a Soil Chemist would probably be appointed in 1937 or 1938.

ACCOUNTS

(*a*) Statement of Receipts and Payments of the Board for the 4th quarter, 1935 and of the London Advisory Committee for the 3rd and 4th quarters, 1935, were adopted.

(*b*) Balance Sheet and Income and Expenditure A/c and Auditor's Report for 1935 were adopted and supplementary votes passed to cover excesses of expenditure on 1935 estimates.

(*c*) Unexpended balances of capital votes passed in 1935 totalling Rs. 54,761·00 were re-voted.

(*d*) A list of unserviceable articles written off the inventory in 1935 was tabled.

(*e*) Dartonfield and Nivitigalakele Accounts for October, November and December 1935 were tabled.

(*f*) Furniture lists of Senior, Junior and Superintendent's bungalows were tabled.

(*g*) Payment of a gratuity of Rs. 20·00 to the rubber-maker of Kandanuwara Estate, Matale, for supervision of latex measurements in connection with Oidium experiments in 1935 was sanctioned.

(*h*) Reported renewal of fixed deposits totalling Rs. 105,000·00 and transfer to current a c of deposits totalling Rs. 40,000·00 to meet anticipated expenditure on buildings.

ANNUAL REPORT 1935 was adopted.

STAFF

(*a*) *Mr. W. I. Pieris' new agreement.*—Reported that this had been signed and the Board's seal on it authenticated by the Acting Chairman and Mr. Collins.

(*b*) *Mr. T. E. H. O'Brien's agreement.* Leave terms decided on at the last meeting were confirmed.

(c) *Junior Staff.*—Changes in laboratory and estate staff were reported.

Sick leave taken in excess of the prescribed period by two officers was allowed.

EXPERIMENTAL COMMITTEE

A. Mr. E. W. Whitelaw's resignation was noted with regret and Mr. C. E. A. Dias was appointed to fill the vacancy.

B. Col. T. G. Jayewardena, who had vacated his seat by reason of absence from three consecutive meetings of the Committee, was re-instated.

C. Mr. I. L. Cameron gave notice of his resignation from the Committee owing to pressure of other work.

D. The Committee's recommendation that the publications of the Scheme should be sent to the Algemeen Landbouw Syndicaat was approved.

E. The Committee's recommendation regarding revision of technical handbooks was approved, but it was agreed that action would have to be deferred until Mr. O'Brien's return from leave.

It was decided to obtain a number of copies of the Malayan Rubber Research Institute's Planting Manual No. 5, entitled "The history and description of clones of Hevea Brazliensis" for sale locally in view of the prevailing interest in replanting.

F. The Committee's recommendation that technical officers' progress reports should in future be issued at quarterly instead of monthly intervals was approved.

G. The Committee's recommendation that a charge should be made for electric current supplied to officers' bungalows and that they should not be allowed to instal appliances which consume a large quantity of power was approved.

H. *Visitors' day at Dartonfield.*—The following recommendations of the Committee were approved.

That there should be fixed visitors' days and that the Estate Superintendent should be available each Wednesday and the Technical Officers on the 2nd and 4th Wednesdays of each month in order to show visitors round the estate.

That intending visitors should be asked to arrive by 9·30 a.m.

That explanatory notice boards should be provided in each experimental area.

I. Approach road to Dartonfield—It was decided to apply to Government for a grant for maintenance of the road.

J. 1936 Replanting Experiment—It was decided that an experiment for measuring erosion from the contour drained areas by installing cement tanks to collect silt should be undertaken as soon as possible.

SMALL HOLDINGS WORK

A Sub-Committee consisting of the two representatives of small holders on the Board, the Director of Research and the Small Holdings Officer was appointed to consider the organisation of small-holdings work. In order to obviate delay in the work of the Small Holdings Officer the Committee was authorised to appoint one instructor before its report is considered by the Board.

The meeting closed with a vote of thanks to the chair.

REVIEW

Scientific Horticulture—*The Journal of The Horticultural Education Association. Volume IV*, 1936.—Price 3s. 6d.

THIS compilation, formerly the Horticultural Education Association Year Book, affords most valuable information to the horticulturist in temperate regions and much, with adaptation, applies also to horticultural enterprises in other zones.

The unity of theory and practice is well illustrated in this compilation. Horticultural science in England, though yet in its youth, makes rapid strides assisted as it is by the Institutes at Long Ashton, East Malling, Wye and Wisley among others.

Dealing in particular with horticulture in North Wales the President deplores the tendency, since the majority of horticultural workers are drawn from the elementary and secondary schools, of such schools being placed to too great an extent in the towns or populous districts rather than bringing the town children into the country, thereby suggesting to the youth during his impressionable age that town life is everything and country life something to leave behind.

Ceylon, with its rural education schemes and school gardens representing rural interests, would appear to be taking the first steps in the right direction.

Commercial horticulture in Sussex and papers on market gardens with tomato and potato growing and raspberry growing in Scotland affords interesting reading, but of more interest locally is Prof. R. J. D. Graham's paper to the West of Scotland Agricultural College on vegetative reproduction by means of rooted cuttings. Many instances are afforded of the various methods employed, and necessary, with different types of plants. With the host of exotic plants in Ceylon, of economic and ornamental value which fail to produce seed and must necessarily be propagated by vegetative means, these methods afford a new guide. Generally the main principles advocated and to which attention must initially be given are (*a*) selection of plant portion for cutting, (*b*) preparation and insertion of the cutting, (*c*) creation of a suitable environment for the cutting and (*d*) an observance of any special features displayed by the cutting. Our local difficulties in this respect include such useful plants as the Amherstia, Citrus (other than Lemon), Hevea, Cinchona and Camphor. The presence of essential oil, latex and such like known factors which usually hinder propagation are dealt with in the

paper and the mode by which such is overcome is explained. The methods embrace nodal and internodal rooting, blanching or "etiolation" of the stem, with treatment of cuttings of large pith area in the stem, leaf cuttings, lateral buds and many other relative practices. Propagation by root cuttings is touched upon though not in detail but this is becoming more in vogue locally with the rare and beautiful flowering tree *Tecoma araliacea*, the Breadfruit (*Artocarpus incisa*) and others, whereby small lateral roots of pencil thickness and 6 in. to 8 in. in length are inserted to form four-fifths of their length in sand, either in beds or when necessary, as with Tecoma, in bottom heat.

A new method of hastening flowering of winter cereals—vernalization—is dealt with by Miss O. N. Purvis of the Imperial College of Science, London, in the practical and theoretical aspects of this Russian method. Local experiments on similar lines on the effect of vernalisation on rice have been reported in *The Tropical Agriculturist*, Vol. LXXXV, No. 6 and Vol. LXXXIII, No. 6. A differentiation is observed between the seed treatment required for "long day" plants such as temperate cereals and "short day" plants such as millet, sorghum, cotton and soya bean. Investigations in Holland on vernalization of flowering bulbs are in hand on the effects of temperature and humidity conditions during the period of storage subsequent to the lifting of the bulbs, the object being to accelerate and improve flower production. It would appear that work on vernalization applied to many horticultural subjects would materially assist in the growing of plants in environments to which they are not naturally suited.

Further subjects dealt with are, seedling growth in partially sterilised soils, and the origin and work of the Board of Greenkeeping Research. This latter Research Board, formulated at the instigation of the Green Committee of the Royal and Ancient Golf Club in 1924, has much to its credit. To the visitor from the tropics who is necessarily restricted in his own efforts by lack of varieties of grass, by unsuitable soil and extreme climatic conditions, the wonderful swathes of turf to be seen on the golf links, bowling greens and private gardens in temperate countries is a source of wonder. The function of the Board is to enquire into the best methods of establishing and maintain- sport purposes and for advisory service to members, supported by publications, ing turf for lectures and demonstrations. The recent leather jacket attack on England's principal cricket field must have afforded scope to its committee. Proper aeration and manuring are subjects dealt with in detail in the article.

The journal this year, as on previous occasions, is a very interesting and up to date volume and the production of a publication on similar lines on tropical research work would fill a long felt need.—T.H.P.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED APRIL, 1936.

Province, &c.	Disease	No. of Cases up to date since Jan. 1st, 1936	Fresh Cases	Recoveries	Deaths	Balance Ill	No. Shot
Western	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	83	81	2	..	81	..
	Anthrax	..	..	..	..	..	..
	Rabies	11	1	..	..	..	11
Colombo Municipality	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	972	972	684	7	281	..
	Anthrax	1	1	..	1	..	..
	Rabies	21	4	..	21	..	..
Cattle Quarantine Station	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	..	..	..	..	..	..
	Anthrax	14	5	..	14	..	..
Central	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	967	558	915	9	43	..
	Anthrax	4	4	..	4	..	..
	Tuberculosis	1	1	..	1	..	..
	Piroplasmosis	1	1	..	..	1	..
Southern	Rinderpest Foot-and-mouth disease Anthrax	FREE					
Northern	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	243	190	221	3	19	..
	Anthrax	..	..	..	..	..	..
Eastern	Rinderpest Foot-and-mouth disease Anthrax	FREE					
North-Western	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	383	79	349	1	33	..
	Anthrax	..	..	..	..	..	..
	Rabies	17	2	..	1	..	16
North-Central	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	637	66	582	..	55	..
	Anthrax	..	..	..	..	..	..
Uva	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	..	..	..	..	..	..
	Anthrax	..	..	..	..	..	..
	Rabies	..	..	..	..	..	..
Sabaragamuwa	Rinderpest	..	..	..	..	..	..
	Foot-and-mouth disease	..	..	..	..	..	..
	Anthrax	..	..	..	..	..	..
	Haemorrhagic Septicaemia	3	3	..	3	..	..
	Rabies	2	2	..	..	..	2

Government Veterinary Department,
Peradeniya, 15th May, 1936.

M. CRAWFORD,
Government Veterinary Surgeon.

METEOROLOGICAL REPORT—APRIL, 1936

Station	Temperature				Humidity		Amount of Cloud	Rainfall		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Ins.		Ins.
Colombo ..	89·0	+1·4	77·2	+1·5	68	86	6·6	2·86	8	− 6·02
Puttalam ..	90·8	+1·8	77·5	+1·7	70	89	4·2	0·38	2	− 4·51
Mannar ..	89·9	−1·3	79·2	+1·4	70	85	4·1	0·29	2	− 2·84
Jaffna ..	89·6	+0·3	81·0	+1·1	73	82	3·4	1·87	1	+ 0·38
Trincomalee ..	91·3	+2·3	78·7	+1·3	67	84	4·9	0·02	1	− 1·97
Batticaloa ..	88·6	+0·8	78·0	+1·7	72	89	5·8	0·27	1	− 1·48
Hambantota ..	88·7	+1·3	77·2	+1·3	74	89	4·4	2·09	6	− 1·22
Galle ..	86·4	+0·2	77·8	+1·3	76	86	6·0	4·34	11	− 4·44
Ratnapura ..	93·5	+2·4	74·4	+0·8	75	93	5·2	1·20	10	− 10·04
Anuradhapura ..	92·0	+0·9	75·8	+1·8	66	93	5·8	0·91	4	− 4·95
Kurunegala ..	91·5	+0·4	75·4	+1·0	66	88	5·0	1·07	4	− 8·38
Kandy ..	88·9	+1·3	70·2	+0·4	68	92	4·3	1·72	4	− 4·51
Badulla ..	85·8	+1·8	66·2	+0·2	66	95	4·8	0·46	6	− 5·96
Diyatalawa ..	79·8	+2·0	59·4	−0·5	67	91	5·3	4·63	11	− 0·61
Hakgala ..	76·0	+1·6	53·5	−0·5	73	85	5·5	1·59	7	− 5·55
Nuwara Eliya ..	71·5	0	46·1	−2·7	64	96	5·5	0·42	6	− 4·24

The rainfall of April was below normal throughout the Island, only a very few stations reporting any excesses. The highest deficits were recorded by a few stations in Sabaragamuwa, while practically the whole of the western low-country from Galle to Anuradhapura and a large portion of the hills had deficits between 5 and 10 inches. The Jaffna Peninsula and the eastern and southern coastal districts had the lowest deficits. The highest monthly total was 15·51 inches from Koslanda.

Only one daily fall of over 5 inches was reported, *viz.*, 5·46 inches at Udahena on the 1st.

The widespread rain towards the end of March gradually decreased and a dry spell set in on the 6th and ended about the 10th, when there was again rain in the southern half of the Island. This was fairly heavy and widespread on the 13th-15th and lasted till the 20th. Another dry spell with unusually warm nights set in on the 22nd and continued till about the end of the month. Thunderstorm activity was in evidence during the first three weeks and the rains were mainly due to this.

Mean monthly temperatures were above normal except the minimum temperatures up-country. Relative humidity was about normal by day and below normal by night. Pressure was a little below normal except in the south-west and the mean gradient was weak. Wind strength was above normal, particularly in the last week when the direction was chiefly westerly. During the rest of the month the wind direction was variable.

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